KANSAS LAKE AND WETLAND MONITORING PROGRAM

2016 ANNUAL REPORT

Division of Environment
Bureau of Water
Watershed Planning, Monitoring, and Assessment Section
1000 SW Jackson Street, Suite 420
Topeka, KS 66612

By
G. Layne Knight

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EXECUTIVE SUMMARY

The Kansas Department of Health and Environment (KDHE) Lake and Wetland Monitoring Program surveyed the water quality conditions of 40 Kansas lakes and wetlands during 2016. Eight of the sampled waterbodies are large federal impoundments, ten are State Fishing Lakes (SFLs), eighteen are city and county lakes, three are federal wetland areas, and one is a state wetland area. In addition, a single sample was taken from Big Spring; a prominent water resource at Scott State Park.

Of the 33 lakes and wetlands analyzed for chlorophyll concentrations, 74% exhibited trophic state conditions comparable to their previous period-of-record water quality conditions. Another 13% exhibited improved water quality conditions, compared to their previous period-of-record, as evidenced by a lowered lake trophic state. The remaining 13% exhibited degraded water quality, as evidenced by elevated lake trophic state conditions. Phosphorus was identified as the primary factor limiting phytoplankton growth in 50% of the lakes surveyed during 2016, nitrogen was identified as the primary limiting factor in about 20% of the lakes and wetlands, while five lakes (15%) were identified as primarily light limited due to higher inorganic turbidity. Two lakes were determined to be limited by hydrologic conditions and one lake had algal limitation due to extreme macrophyte densities. Limiting factors were unable to be determined for the remaining two lakes.

A total of 23 waterbodies had trophic state conditions sufficiently elevated to cause impairment of one or more designated uses. Of these, 20 lakes and wetlands (61% of all waterbodies) had trophic state conditions sufficient to create moderate-to-severe water quality problems in multiple designated uses. Although present, water quality criteria exceedances related to heavy metals and pesticides, salinity, or other inorganic parameters were relatively few in number during 2016.

Twenty-seven waterbodies (79% of those surveyed for pesticides) had detectable levels of at least one pesticide during 2016. Atrazine was detected in 22 of these waterbodies, once again making atrazine the most commonly documented pesticide in Kansas lakes. The highest observed atrazine concentration during lake and wetland sampling was 10.0 µg/L. A total of six different pesticides were found in lakes during 2016.

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INTRODUCTION

Development of the Lake and Wetland Monitoring Program

The Kansas Department of Health and Environment (KDHE) Lake and Wetland Monitoring Program was established in 1975 to fulfill the requirements of the 1972 Clean Water Act (Public Law 92-500) by providing Kansas with background water quality data for water supply and recreational impoundments, determining regional and time trends for those impoundments, and identifying pollution control and/or assessment needs within individual lake watersheds.

Program activities originally centered around a small sampling network comprised mostly of federal lakes, with sampling stations at numerous locations within each lake. In 1985, based on the results of statistical analyses conducted by KDHE, the number of stations per lake was reduced to a single integrator station within the main body of each impoundment. This, and the elimination of parameters with limited interpretive value, allowed expansion of the lake network to its present 177 sites scattered throughout all the major drainage basins and physiographic regions of Kansas. The network remains dynamic, with lakes occasionally being added to or dropped from active monitoring or replaced with more appropriate sites throughout the state.

2016 Monitoring Activities

Staff of the KDHE Lake and Wetland Monitoring Program visited 41 Kansas lakes and wetlands during 2016. Eight of these waterbodies are large federal impoundments last sampled in 2014, ten are State Fishing Lakes (SFLs), eighteen are city/county lakes (CLs and Co. Lakes, respectively), three are federal wetland areas and two are state wetland areas. Big Spring at Scott SFL also was sampled. Fifteen of the 36 lakes (42%) presently serve as either primary or back-up municipal or industrial water supplies, have an existing municipal water supply allocation, or have public water supply wells along their shores. Although 42 sites were visited, samples were collected from only 34 locations. Four lakes (Finney Co. SFL, Hain SFL, Logan CL, and Logan Co. SFL) were determined to be intermittent in nature and will not be re-scheduled for routine monitoring activities. Lakes such as these may, in following years, be targeted for a less intensive monitoring event of chlorophyll-a, dissolved oxygen, and temperature. Three of the targeted federal wetlands (Flint Hills NWR, Kirwin NWR, and Marais des Cygnes NWR) did not have water during the time of the visit and one state owned wetland (Marais des Cygnes WA) had a low water level due to maintenance construction activities. Many of the sites that did not have sufficient water were included in 2016 as exploratory sites in an effort to expand the number of monitored locations.

General information on the lakes surveyed during 2016 is compiled in Table 1. Figure 1 depicts the distribution of classified lakes and wetlands in Kansas and details those waterbodies sampled during 2016.

Table 1. General information pertaining to lakes and wetlands surveyed during 2016.

Waterbody	Basin	Authority	Water Supply	Last Survey
Alma City Lake	Kansas-Republican	City	Yes	1993
Antelope Lake	Smoky-Saline	County	No	2008
Atchison Co. Park Lake	Kansas-Republican	County	No	2010

Waterbody	Basin	Authority	Water Supply	Last Survey
Big Hill Lake	Verdigris	Federal	Yes	2014
Big Spring	Smoky-Saline	State	No	2013
Central Park Lake	Kansas-Republican	City	No	2010
Concannon State Fishing Lake	Upper Arkansas	State	No	2002
Crystal Lake	Marais des Cygnes	City	Yes	2006
Elk City Lake	Verdigris	Federal	Yes	2014
Fall River Lake	Verdigris	Federal	Yes	2014
Ford Co. Lake	Upper Arkansas	County	No	2009
Gridley City Lake	Neosho	City	No	2005
Hodgeman Co. State Fishing Lake	Kansas-Republican	State	No	N/A
Horsethief Canyon Lake	Upper Arkansas	County	No	2013
Jamestown Wildlife Area	Kansas-Republican	State	No	2014
Jetmore Lake	Neosho	City	Yes	2010
Jewell Co. State Fishing Lake	Solomon	State	Yes	2010
Kiowa Co. State Fishing Lake	Lower Arkansas	State	No	1991
Kirwin Lake	Solomon	Federal	No	2015
La Cygne Lake	Marais des Cygnes	County	No	1992
Lake Coldwater	Cimarron	City	No	2005
Lake Jewell	Lower Arkansas	City	No	2010
Lovewell Lake	Kansas-Republican	Federal	No	2014
New Alma City Lake	Kansas-Republican	City	Yes	2008
Norton Lake	Upper Republican	Federal	Yes	2014
Otis Creek Lake	Verdigris	Private/RWD	Yes	2008
Pleasanton Reservoir	Marais des Cygnes	City	Yes	2015
Prairie Lake	Kansas-Republican	County	Yes	2007
Scott State Fishing Lake	Smoky-Saline	State	No	2013
Toronto Lake	Verdigris	Federal	Yes	2014
Veteran's Lake	Verdigris	City	No	2013
Waconda Lake	Solomon	Federal	Yes	2014
Wolf Creek Lake	Neosho	County	No	2008
Xenia Lake	Kansas-Republican	Private/RWD	Yes	N/A

Artificial lakes often are termed “reservoirs” or “impoundments,” depending on whether they are used for drinking water supply or for other beneficial uses, respectively. In many parts of the country, smaller lakes are termed “ponds” based on arbitrary surface area criteria. To provide consistency, this report uses the term “lake” to describe all lentic, non-wetland, bodies of standing water within the state. The only exception to this is when more than one lake goes under the same general name. For example, the City of Herington has jurisdiction over two larger lakes. The older lake is referred to as Herington City Lake while the newer one is called Herington Reservoir in order to distinguish it from its sister waterbody. While it is recognized that the vast majority of lentic waters in Kansas are of artificial origin, use of the term “lake” also emphasizes that our artificial lentic waterbodies provide most (if not all) of the functions and beneficial societal uses supported by natural lakes. For a significant number of Kansas lakes, except for the presence of a constructed dam, there are more physical similarities to natural systems than differences (i.e., volume/depth ratio, point of discharge, watershed/lake area ratio, etc.).

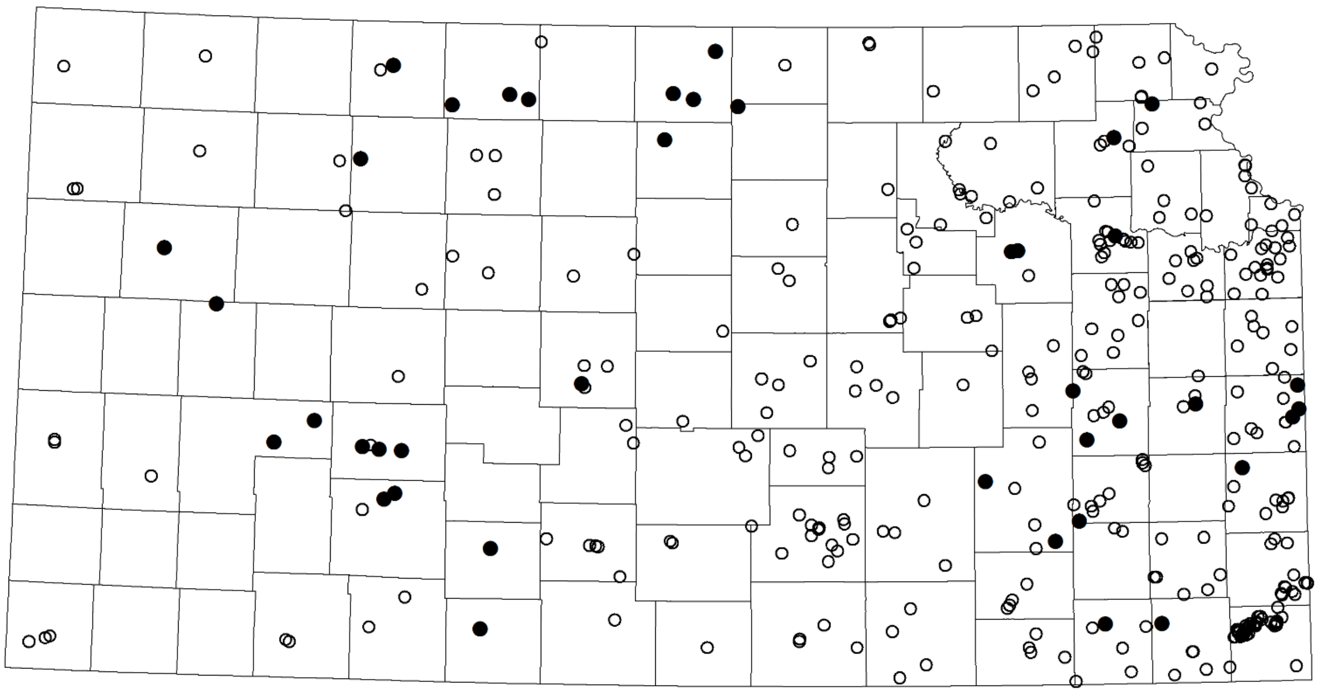

Figure 1. Map of Kansas depicting the distribution of classified lakes and wetlands in Kansas (open circles) and detailing those waterbodies sampled during 2016 (filled circles).

METHODS

Yearly Selection of Monitored Sites

Since 1985, the 24 large federal lakes in Kansas have been arbitrarily partitioned into three groups of eight. Each group is normally sampled only once during a three year period of rotation. Around 25-to-30 smaller lakes are sampled each year in addition to that year's block of eight federal lakes. These smaller lakes have historically been chosen based on three considerations: 1) Are there recent data available (within the last 3-4 years) from KDHE or other programs?; 2) Is the lake showing indications of pollution that require enhanced monitoring?; or 3) Have there been water quality assessment requests from other administrative or regulatory agencies (state, local, or federal)? Several lakes have been added to the network due to their relatively unimpacted watersheds. These lakes serve as ecoregional reference, or "least impacted," sites (Dodds et al., 2006).

In an effort to incorporate a larger percentage of classified waterbodies into the regular network, the 358 lakes and wetlands on the Kansas Surface Water Register were subjected to a hierarchical ranking procedure during 2015 and 2016. Appendix A describes this analysis in greater detail.

Sampling Procedures

At each lake, a boat is anchored over the inundated stream channel near the dam. This point is referred to as Station 01, and represents the area of maximum depth. Duplicate water samples are taken by Kemmerer sample bottle 0.5 meters below the surface for determination of basic inorganic chemistry (major cations and anions), algal community composition, chlorophyll-a, nutrients (ammonia, nitrate, nitrite, Kjeldahl nitrogen, total organic carbon, and total and ortho phosphorus), and total recoverable metals/metalloids (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, uranium, vanadium, and zinc). In addition, a single pesticide sample, and duplicate *Escherichia coli* bacteria samples, are collected at 0.5 meters depth at the primary sampling point (KDHE, 2017). At the 24 federal lakes, a single water sample also is taken 0.5 to 1.0 meter above the lake substrate for determination of inorganic chemistry, nutrients, and metals/metalloids within the hypolimnion.

At each lake, measurements are made at Station 01 for determination of temperature and dissolved oxygen profiles, field pH, field conductivity, and Secchi depth. All samples are preserved and stored in the field in accordance with KDHE quality assurance/quality control protocols (KDHE, 2017). Field measurements, chlorophyll-a analyses, and algal taxonomic determinations are conducted by staff of KDHE's Monitoring and Analysis Unit of the Bureau of Water. All other analyses are carried out by the Kansas Health and Environmental Laboratory (KHEL).

Since 1992, macrophyte surveys have been conducted at each of the smaller lakes (<250 acres) within the KDHE Lake and Wetland Monitoring Program network. These surveys entail the selection and survey of 10-to-20 sampling stations, depending on total surface area and lake morphometry. Stations are distributed in a grid pattern over the lake surface. At each sampling point, a grappling hook is cast to rake the bottom for submersed aquatic plants. This process, combined with visual observations, confirms the presence or absence of macrophytes at each station. If present, macrophyte species are identified and recorded on site. Specimens that cannot be identified in the field are placed in labeled plastic bags, on ice, and transported to the KDHE Topeka office. Presence/absence and taxon specific presence/absence data are used to calculate spatial coverage (percent distribution) estimates for each lake (KDHE, 2017).

In the event that boat access is not available, or the site is one selected for reduced sampling (see Appendix A), water samples may be taken from an elevated structure over the water surface (e.g., boat dock, walkway, etc.) using a Kemmerer bottle or simply from shore using an extendable pole with an attached sampling cup.

Results and Discussion

Trophic State and Algal Community

The Carlson Trophic State Index (TSI) provides a useful tool for the comparison of lakes in regard to general ecological functioning and level of productivity (Carlson, 1977). Since chlorophyll-a TSI scores are based on the planktonic algae community, production due to macrophyte beds is not reflected in these scores. The system used to assign lake trophic state, based on TSI scores, is presented below. Trophic state classification is adjusted for macrophytes where percent areal cover (as estimated by percent presence) is greater than 50%, and where visual bed volume and plant density clearly indicate that macrophyte productivity contributes significantly to overall lake primary production. Mean chlorophyll-a for the 2016 surveys was 32.27 ug/L (hypereutrophic). The median chlorophyll-a was 26.55 ug/L (very eutrophic). Table 2 presents TSI scores for the 33 network lakes surveyed during 2016, previous TSI mean scores for those lakes with past data, and an indication of the extent that lake productivity is dominated by submersed and floating-leaved vascular plant communities (macrophytes).

TSI score of 0-39 = oligo-mesotrophic (OM)

OM = A lake with a low level of planktonic algae. Such lakes also lack significant amounts of suspended clay particles in the water column, giving them a relatively high level of water clarity. These lakes often have robust submersed macrophyte communities. Chlorophyll-a concentration averages no more than 2.60 ug/L.

TSI score of 40-49 = mesotrophic (M)

M = A lake with only a moderate planktonic algal community. Water clarity remains relatively high. Chlorophyll-a ranges from 2.61 to 7.20 ug/L.

TSI score of 50-64 = eutrophic (E)

E = A lake with a moderate-to-large algae community. Chlorophyll-a ranges from 7.21 to 29.99 ug/L. This category is further divided as follows:

TSI = 50-54 = slightly eutrophic (SE) Chlorophyll-a ranges 7.21 to 11.99 ug/L,

TSI = 55-59 = fully eutrophic (E) Chlorophyll-a ranges 12.00 to 19.99 ug/L,

TSI = 60-64 = very eutrophic (VE) Chlorophyll-a ranges 20.00 to 29.99 ug/L.

TSI score of >64 = hypereutrophic (H)

H = A lake with a very large phytoplankton community. Chlorophyll-a averages more than 30.00 ug/L. This category is further divided as follows:

TSI = 64-69.9 = lower hypereutrophic (LH) Chlorophyll-a ranges 30.00 to 55.99 ug/L,

TSI = >70 = upper hypereutrophic (UH) Chlorophyll-a values >56.00 ug/L.

TSI score not relevant

Argillotrophic (A)

A = In a relatively small number of Kansas lakes (4% of public lakes at the last accounting), high turbidity due to suspended clay particles restricts the development of a phytoplankton community. In such cases, nutrient availability remains high, but is not fully translated into algal productivity or biomass due to light limitation. Lakes with such high turbidity and nutrient levels, but lower than expected algal biomass, are called argillotrophic (Naumann, 1929). These lakes typically have chronically high turbidity. Frequent wind resuspension of sediments, as well as benthic feeding fish communities (e.g., common carp) to a generally lesser degree, contribute to these chronic conditions. During periods of calm winds, these lakes may temporarily become hypereutrophic as light limitation is relaxed due to settling of suspended solids. Argillotrophic lakes also tend to have very small, or nonexistent, submersed macrophyte communities. Mean chlorophyll-a concentrations do not exceed 7.20 ug/L as a general rule.

Dystrophic (D)

D = Similar to argillotrophic lakes, dystrophic lakes can be nutrient rich, but are light limited. The difference lies in the fact that a dystrophic waterbody is highly colored by humic/organic dissolved matter, resulting in potentially lower than expected chlorophyll-a values.

All Carlson chlorophyll TSI scores are calculated by the following formula, where C is the phaeophytin-corrected chlorophyll-a level in ug/L (Carlson, 1977):

$$TSI = 10(6-(2.04-0.68\log_e(C))/\log_e(2)).$$

Table 2. Current and past TSI scores and trophic state classification for the lakes surveyed during 2016. Trophic class abbreviations used previously apply. Macrophytes accounted for a significant portion of primary production in Concannon SFL. Adjusted assigned trophic classes due to macrophytes or light limitations appear in parentheses. Previous TSI scores are based solely on algal chlorophyll TSI scores.

Waterbody	2016 TSI	2016 Class	Period-of-Record Mean TSI	Previous Class
Concannon State Fishing Lake	32.36	OM (VE)	66.86	LH
Otis Creek Lake	42.28	M	46.36	M
New Alma City Lake	45.57	M	41.98	M
Xenia Lake	46.02	M	NA	NA
Ford County Lake	47.35	M (D)	77.83	UH
Alma City Lake	48.15	M	58.49	E
Wolf Creek Lake	48.71	M	51.90	SE
Pleasanton Reservoir	50.53	SE	57.91	E
Toronto Lake	52.52	SE (A)	54.82	SE
Kiowa Co. State Fishing Lake	53.82	SE (A)	61.85	VE
Lake Coldwater	55.85	E	62.43	VE
Prairie Lake	57.81	E	54.97	SE
Big Hill Lake	58.36	E	55.10	E
Elk City Lake	60.05	VE	58.96	E
Horsethief Canyon Lake	60.21	VE	59.36	E
Jewell Co. State Fishing Lake	62.35	VE	61.08	VE
Jetmore Lake	62.73	VE	68.64	LH
Gridley City Lake	62.92	VE	60.35	VE
Kirwin Lake	63.01	VE	59.40	E
Atchison County Park Lake	63.24	VE	63.81	VE
Fall River Lake	63.28	VE	52.72	SE
Waconda Lake	63.34	VE	58.05	E
Lake Jewell	65.81	LH	71.66	UH
Scott State Fishing Lake	67.21	LH	77.15	UH
Norton Lake	69.40	LH	58.54	E
Lovewell Lake	69.72	LH	63.91	VE
La Cygne Lake	70.07	UH	63.36	VE
Veteran's Lake	70.98	UH	72.61	UH
Antelope Lake	71.01	UH	56.10	E
Hodgeman Co. State Fishing Lake	71.52	UH	NA	NA

Waterbody	2016 TSI	2016 Class	Period-of-Record Mean TSI	Previous Class
Crystal Lake	72.56	UH	70.95	UH
Central Park Lake	75.17	UH	67.89	LH
Jamestown Wildlife Area	78.33	UH	78.18	UH

The composition of the algal community (structural feature) often gives a better ecological picture of a lake than relying solely on a trophic state classification (functional feature). Table 3 presents both total algal cell count and percent composition of several major algal groups for the lakes surveyed in 2016. Lakes in Kansas that are nutrient enriched tend to be dominated by green or blue-green algae, while those dominated by diatom communities may not be so enriched. Certain species of green, blue-green, diatom, or dinoflagellate algae may contribute to taste and odor problems in finished drinking water, when present in large numbers in water supply lakes and streams. The mean algal cell count among the 34 lakes this year was 86,807 cells/mL (median = 16,097 cells/mL), significantly higher than in most recent years.

Table 4 presents total biovolume and percent composition data for the 34 waterbodies surveyed in 2016. When considered along with cell counts, biovolume data are useful in determining which algae species or algae groups actually exert the strongest ecological influence on a lake. The mean algal biovolume among lakes this year was 21.035 ppm (median = 9.142 ppm).

Table 3. Algal communities observed in the lakes surveyed during 2016. The "other" category refers to euglenoids, cryptophytes, dinoflagellates, and other single-celled, flagellated algae.

Waterbody	Cell Count	Percent Composition			
	(cells/mL)	Green	Blue-Green	Diatom	Other
Alma City Lake	8,127	31.8	65.9	0.8	1.6
Antelope Lake	5,922	55.3	16.0	14.9	13.9
Atchison Co. Park Lake	36,729	7.5	89.2	2.9	0.3
Big Hill Lake	45,486	1.5	97.5	1.0	0.0
Big Spring	441	0.0	57.1	42.9	0.0
Central Park Lake	229,257	5.4	93.2	1.2	0.3
Concannon State Fishing Lake	315	20.0	80.0	0.0	0.0
Crystal Lake	457,002	2.8	96.9	0.2	0.2
Elk City Lake	6,048	8.3	34.4	53.1	4.1
Fall River Lake	9,450	4.0	62.7	32.0	1.3
Ford Co. Lake	10,962	23.0	73.0	3.4	0.6
Gridley City Lake	29,610	22.1	62.8	14.0	1.1
Hodgeman Co. State Fishing Lake	635,985	0.1	99.8	0.1	0.1
Horsethief Canyon Lake	15,498	27.6	68.3	0.0	4.1
Jamestown Wildlife Area	342,720	2.0	93.2	2.9	1.9
Jetmore Lake	105,714	19.7	80.3	0.0	0.0
Jewell Co. State Fishing Lake	24,003	31.2	66.9	1.8	0.0
Kiowa Co. State Fishing Lake	1,953	67.7	0.0	0.0	32.3
Kirwin Lake	16,695	43.4	53.2	1.9	1.5
La Cygne Lake	196,560	0.0	98.9	1.1	0.0
Lake Coldwater	14,175	99.6	0.0	0.0	0.4
Lake Jewell	80,577	17.7	76.6	4.6	1.0
Lovewell Lake	75,096	2.6	86.2	11.0	0.3
New Alma City Lake	2,646	0.0	52.4	45.2	2.4
Norton Lake	15,120	75.0	0.0	23.3	1.7
Otis Creek Lake	4,410	5.7	91.4	1.4	1.4
Pleasanton Reservoir	8,379	16.5	81.2	1.5	0.8
Prairie Lake	12,852	50.0	48.5	0.0	1.5

Waterbody	Cell Count (cells/mL)	Percent Composition			
		Green	Blue-Green	Diatom	Other
Scott State Fishing Lake	137,340	0.6	98.2	0.9	0.3
Toronto Lake	3,843	11.5	37.7	47.5	3.3
Veteran's Lake	311,094	2.4	97.0	0.4	0.2
Waconda Lake	42,336	12.6	82.3	4.0	1.0
Wolf Creek Lake	57,771	0.1	99.1	0.7	0.1
Xenia Lake	7,308	22.4	57.8	16.4	3.4

Table 4. Algal biovolumes calculated for the lakes surveyed during 2016. The "other" category refers to euglenoids, cryptophytes, dinoflagellates, and other single-celled, flagellated algae. Biovolume units are calculated in mm^3/L and expressed as parts-per-million (ppm).

Waterbody	Biovolume (ppm)	Percent Composition			
		Green	Blue-Green	Diatom	Other
Alma City Lake	12.994	17.3	80.5	0.3	1.9
Antelope Lake	3.814	18.1	4.8	22.3	54.9
Atchison Co. Park Lake	13.793	19.4	46.4	26.0	8.3
Big Hill Lake	6.294	4.5	84.0	11.5	0.0
Big Spring	0.16	0.0	30.8	69.2	0.0
Central Park Lake	57.118	5.9	73.0	14.2	6.9
Concannon State Fishing Lake	0.074	33.3	66.7	0.0	0.0
Crystal Lake	86.624	4.8	91.4	2.7	1.1
Elk City Lake	10.545	4.6	3.4	79.8	12.2
Fall River Lake	11.517	1.1	10.0	85.9	3.0
Ford Co. Lake	2.99	36.2	52.3	7.4	4.1
Gridley City Lake	9.376	16.8	38.7	36.1	8.4
Hodgeman Co. State Fishing Lake	124.829	0.1	99.3	0.1	0.5
Horsethief Canyon Lake	8.908	21.5	37.0	0.0	41.4
Jamestown Wildlife Area	116.401	2.3	53.6	19.5	24.6
Jetmore Lake	19.417	26.0	74.0	0.0	0.0
Jewell Co. State Fishing Lake	8.749	17.9	74.7	7.5	0.0
Kiowa Co. State Fishing Lake	3.138	11.8	0.0	0.0	88.3
Kirwin Lake	7.001	52.7	16.3	5.3	25.6
La Cygne Lake	18.241	0.0	96.0	4.0	0.0
Lake Coldwater	7.26	83.1	0.0	0.0	16.9
Lake Jewell	20.302	15.6	59.4	12.2	12.7
Lovewell Lake	16.168	3.1	8.3	80.6	8.0
New Alma City Lake	0.886	0.0	30.6	52.8	16.7
Norton Lake	19.318	63.6	0.0	23.0	13.4
Otis Creek Lake	0.699	14.1	22.5	1.8	61.6
Pleasanton Reservoir	2.264	29.9	58.7	4.3	7.1
Prairie Lake	5.611	27.9	43.4	0.0	28.7
Scott State Fishing Lake	57.228	1.1	85.6	9.1	4.3
Toronto Lake	4.331	4.8	6.5	73.9	14.8
Veteran's Lake	43.952	10.1	78.2	4.9	6.7
Waconda Lake	9.513	38.5	29.4	18.8	13.3
Wolf Creek Lake	3.378	0.4	80.0	13.1	6.6
Xenia Lake	2.313	12.8	35.6	28.2	23.4

Table 5. Temporal trends in trophic state based on comparisons to mean historical condition.

Change in Trophic State Class Compared to Historic Mean*	Number of Lakes	Percent Total
Improved > Two Class Rankings	0	0.0
Improved One Class Ranking	5	15.2
Stable	22	66.6
Degraded One Class Ranking	4	12.1
Degraded > Two Class Rankings	0	0.0
No previous Ranking	2	6.1
Total	33	100.0

* For the purposes of this comparison, argillotrophic and dystrophic systems are considered equivalent to eutrophic, which also is the assessment protocol for nutrient impairments for these systems.

Of the 15 lakes receiving macrophyte surveys, ten (67%) had detectable levels of submersed plant material (Table 6). In these lakes, the most common plant species were pondweeds (*Potamogeton* spp.), water naiad (*Najas guadalupensis*), coontail (*Ceratophyllum demersum*), Eurasian watermilfoil (*Myriophyllum spicatum*), and various species of stonewort algae (*Chara* spp.). Using trophic state data for macrophytes in the literature (Schneider and Melzer, 2003; Lehmann and LaChavanne, 1999; Sladecek, 1973) combined with observed abundance of aquatic plants during 2016, three water bodies merited further assessment of the macrophyte community trophic classification. Two lakes (Jewell Co. SFL, and Scott SFL) were assessed as eutrophic communities and Concannon SFL was assessed as very eutrophic based on only the macrophyte community data. Actual adjustment to lake trophic state classification was only made to Concannon SFL because of the extreme bed density covering the entire bottom of this shallow lake.

Table 6. Macrophyte community structure in the 15 lakes surveyed for macrophytes during 2016. Macrophyte community refers only to the submersed and floating-leaved aquatic plants, not emergent shoreline plants. Percent Total Coverage is the percentage of sampled stations with detected macrophytes. Percent Species Coverage is the abundance estimate for each documented species and is based on frequency of detection. (Note: due to overlap in cover, the sum of the percent species coverages rarely equals the percent total coverage.)

Waterbody	Percent Total Coverage	Percent Species Coverage	Community Composition
Kiowa Co. SFL	30%	30%	*Zannichellia palustris*
Ford Co. Lake	0%		No species observed
Veteran's Lake	0%		No species observed
Prairie Lake	30%	10%	*Potamogeton pectinatus*
		10%	*Potamogeton nodosus*
		10%	*Nelumbo sp.*
Crystal Lake	50%	20%	*Potamogeton foliosus*
		50%	*Ceratophyllum demersum*
Alma City Lake	40%	20%	*Najas guadalupensis*
		30%	*Chara globularis*
		10%	*Chara zeylanica*
		10%	*Potamogeton foliosus*
Central Park Lake	0%		No species observed
Concannon SFL	100%	100%	*Chara zeylanica*
		100%	*Potamogeton pectinatus*

Waterbody	Percent Total Coverage	Percent Species Coverage	Community Composition
New Alma City Lake	88%	63%	*Potamogeton pectinatus*
		75%	*Potamogeton nodosus*
		25%	*Potamogeton amplifolius*
		25%	*Ceratophyllum demersum*
		38%	*Najas guadalupensis*
		25%	*Potamogeton foliosus*
Scott SFL	100%	100%	*Myriophyllum spicatum*
		10%	*Chara zeylanica*
Xenia Lake	70%	60%	*Potamogeton nodosus*
		60%	*Ceratophyllum demersum*
		10%	*Najas guadalupensis*
		60%	*Myriophyllum spicatum*
Gridley City Lake	50%	50%	*Potamogeton foliosus*
		30%	*Potamogeton nodosus*
		20%	*Najas guadalupensis*
		10%	*Ceratophyllum demersum*
Antelope Lake	0%		No species observed
Lake Jewell	0%		No species observed
Jewell Co. SFL	90%	20%	*Potamogeton foliosus*
		90%	*Ceratophyllum demersum*
		40%	*Potamogeton pectinatus*
		60%	*Najas guadalupensis*
		10%	*Chara zeylanica*
		20%	*Potamogeton nodosus*

Perhaps only one of the lakes surveyed in 2016 appeared to have experienced algal limitation due to macrophyte community influences. In general, Kansas lakes are impaired more by a lack of macrophyte habitat than by an overabundance of aquatic plants. Presence of a robust and diverse macrophyte community normally reflects lower levels of human impact in our lakes and is a common feature in many of our reference quality systems. However, some species (*Ceratophyllum demersum*, *Potamogeton crispus*, or *Myriophyllum spicatum*) may attain nuisance proportions as a result of human activities. Dominance by other species that are native, or at least benign naturalized species (*Najas guadalupensis*, other *Potamogeton* spp., or *Chara/Nitella* spp.), generally implies a higher level of ecosystem health.

It should be noted that the method utilized in KDHE macrophyte surveys only allows for qualitative estimates of bed density. Even with fairly high percent presence values, it is rare for bed densities to approach any threshold that would be identified as an impairment. None of the lakes surveyed in 2016 supported bed densities capable of exerting a negative influence on any beneficial lake use.

Interestingly, several of the high-quality lakes contained moderately high rates of percent total coverage (from 50 to 88 percent), however these lakes had diverse communities of aquatic plants that effectively utilized nutrients and potentially lowered the impacts of planktonic algae. New Alma City

Lake was an excellent example of this having 88 percent station coverage, but with a total of six species detected including a rare native pondweed, *Potamogeton amplifolius* (largeleaf pondweed), at 25 percent of the stations.

Lake Stratification and Water Clarity

Stratification is a natural process that may occur in any standing (lentic) body of water, whether that body is a natural lake, pond, artificial reservoir, or wetland pool (Wetzel, 1983). It occurs when sunlight (solar energy) penetrates into the water column. Due to the thermal properties of water, high levels of sunlight (helped by periods of calm winds during the spring-to-summer months) cause layers of water to form with differing temperatures and densities. The cooler, denser layer (the hypolimnion) remains near the bottom of the lake while the upper layer (the epilimnion) develops a higher ambient temperature. The middle layer (the metalimnion) displays a marked drop in temperature with depth (the thermocline), compared to conditions within the epilimnion and hypolimnion. Once these layers of water with differing temperatures form, they tend to remain stable and do not easily mix with one another. This formation of distinct layers impedes, or precludes, the atmospheric reaeration of the hypolimnion, at least for the duration of the summer (or until ambient conditions force mixing). In many cases, this causes hypolimnetic waters to become depleted of oxygen and unavailable as habitat for fish and some other forms of aquatic life. Stratification eventually breaks down in the fall when surface waters cool. Once epilimnetic waters cool to temperatures comparable to hypolimnetic waters, the lake will mix completely once again. Typically occurring in the fall, and sometimes taking only one to two days to complete, this phenomenon is called "lake turnover."

Lake turnover can cause fishkills, aesthetic problems, and taste and odor problems in finished drinking water if the hypolimnion comprises a significant volume of the lake. This is because such a sudden mixing combines oxygen-poor, nutrient-rich, hypolimnetic water with epilimnetic water lower in nutrients and richer in dissolved oxygen. Lake turnover can result in temporary accelerated algal growth, lowering of overall lake oxygen levels, and sudden fishkills. It also often imparts objectionable odors to lake water and tastes and odors to finished drinking water produced from the lake. Thus, the stratification process is an important consideration in lake management.

The "enrichment" of hypolimnetic waters (with nutrients, metals, and other pollutants) during stratification results from the entrapment of materials that sink down from above, as well as materials that are released from lake sediments due to anoxic conditions. The proportion of each depends on the strength and duration of stratification, existing sediment quality, and inflow of materials from the watershed. For the majority of the larger lakes in Kansas, built on major rivers with dependable flow, stratification tends to be intermittent (polymictic), or missing, and the volume of the hypolimnion tends to be small in proportion to total lake volume. These conditions tend to lessen the importance of sediment re-release of pollutants in the state's largest lakes, leaving watershed pollutant inputs as the primary cause of water quality problems.

Presence or absence of stratification is determined by depth profile measurements for temperature and dissolved oxygen concentration taken in each lake. Mean temperature decline rates (for the entire water column) greater than 1.0°C/meter are considered evidence of stronger thermal stratification, although temperature changes may be less pronounced during the initiation phase of stratification. Lakes with strong thermal stratification are more resistant to mixing of the entire water column, pending the cooling of epilimnetic waters in autumn.

The temperature decline rate, however, must also be considered in relation to the particular lake and the shape of the plotted temperature-to-depth relationship. The sharper the discontinuity in the data plot, the stronger the level of thermal stratification. Gradual declines in temperature with depth, through the entire water column, and indistinct discontinuities in data plots are more indicative of weaker thermal stratification. The strength of the oxycline, based on water column dissolved oxygen decline rate and the shape of the data plot, is also used to characterize stratification in lakes. A strong oxycline might be seen by mid-summer in lakes with weak thermal stratification, if the lakes are not prone to wind mixing, and also in shallow unstratified lakes with dense macrophyte beds. In the latter, dissolved oxygen may be very high in the overlying water on a sunny day but decline to almost zero just beneath the macrophyte canopy.

Table 7 presents data related to thermal stratification in the 32 lakes surveyed in 2016. Appendix B provides graphs of temperature and dissolved oxygen depth profiles for the stratified lakes. Table 8 presents data related to water clarity and the light environment within the water column of each lake.

Table 7. Stratification status of the 32 waterbodies surveyed for depth profiles during 2016.

Waterbody	Date Sampled (M/D/YR)	Temperature Decline Rate (°C/meter)	Dissolved Oxygen Decline Rate (mg/L/meter)	Maximum Lake Depth (meters)	Thermocline Depth (meters)
Alma City Lake	6/7/2016	1.08	0.77	12.4	2.0 -5.0
Antelope Lake	8/16/2016	0.00	0.08	3.5	none
Atchison Co. Park Lake	6/21/2016	0.20	0.07	1.5	none
Big Hill Lake	9/6/2016	0.62	0.34	18.2	6.0 -7.0
Central Park Lake	6/6/2016	1.07	2.69	1.6	none
Concannon State Fishing Lake	6/14/2016	0.10	-0.03	1.4	none
Crystal Lake	6/22/2016	2.27	2.39	3.5	none
Elk City Lake	9/6/2016	0.01	0.03	8.0	none
Fall River Lake	8/2/2016	0.50	1.20	6.5	none
Ford Co. Lake	6/27/2016	4.00	2.09	4.3	none
Gridley City Lake	8/3/2016	0.56	2.24	3.1	none
Hodgeman Co. State Fishing Lake	6/13/2016	3.38	2.48	5.5	none
Horsethief Canyon Lake	6/14/2016	0.31	0.71	12.9	none
Jamestown Wildlife Area	8/22/2016	0.00	0.00	0.8	none
Jetmore Lake	6/13/2016	2.50	1.88	5.5	none
Jewell Co. State Fishing Lake	8/22/2016	0.88	0.81	6.7	none
Kiowa Co. State Fishing Lake	6/27/2016	3.73	1.13	2.1	none
Kirwin Lake	8/15/2016	0.11	0.60	8.5	none
La Cygne Lake	7/11/2016	0.19	0.74	9.6	4.0 - 5.0
Lake Coldwater	6/27/2016	0.38	1.24	5.6	none
Lake Jewell	8/22/2016	0.72	1.89	3.2	none
Lovewell Lake	8/23/2016	-0.02	0.03	6.8	none
New Alma City Lake	6/7/2016	0.87	0.68	13	2.0 - 4.0
Norton Lake	8/15/2016	0.14	0.21	7.3	none
Pleasanton Reservoir	6/22/2016	1.65	0.93	8.5	3.0 - 4.0
Prairie Lake	6/21/2016	1.85	1.02	7.0	2.0 - 4.0
Scott State Fishing Lake	7/5/2016	0.80	2.99	3.7	none
Toronto Lake	8/2/2016	0.27	0.78	6.9	none
Veteran's Lake	6/28/2016	0.07	0.10	3.9	none
Waconda Lake	8/16/2016	0.11	0.37	14.7	none

Waterbody	Date Sampled (M/D/YR)	Temperature Decline Rate (°C/meter)	Dissolved Oxygen Decline Rate (mg/L/meter)	Maximum Lake Depth (meters)	Thermocline Depth (meters)
Wolf Creek Lake	8/3/2016	0.51	0.39	20.8	8.0 - 9.0
Xenia Lake	7/11/2016	1.43	0.66	13.0	4.0 - 6.0

Euphotic depth, or the depth to which light sufficient for photosynthesis penetrates the water column, can be calculated from relationships derived from Secchi depth and chlorophyll-a data (Scheffer, 1998). This report presents the ratio of calculated euphotic depth to calculated mixing depth (Walker, 1986). Mixing depth is the maximum depth to which wind circulation (and thermal stratification) should typically occur. This metric supplies a means to interpret light and algal production relationships in a lake, provided other factors (such as depth and thermal stratification) are also considered simultaneously. For instance, a very high ratio may mean a lake is exceptionally clear, or it may mean it is very shallow and well mixed. A very low value likely means the lake is light limited due to inorganic turbidity or self-shaded due to high algal biomass near the surface.

The calculated euphotic-to-mixed depth ratios suggest that light penetrated throughout the mixed zone in about half of the 34 waterbodies surveyed in 2016 (mean ratio = 3.32, median ratio = 1.06). This also implies that most of the lakes did not experience significant light limitation, because sunlight permeates most, or all, of the epilimnion. Although the accompanying Secchi depth and calculated non-algal turbidity data show slightly elevated turbidity overall (Secchi depth: mean = 85 cm, median = 72 cm; non-algal turbidity: mean = 1.96 m^{-1}, median = 1.40 m^{-1}) (see Walker, 1986), much of this is due to the inclusion of several turbid, yet very shallow systems. Typically, light availability is not limited in these types of waterbodies because of sufficient mixing.

Table 8. Water clarity metrics for the 33 waterbodies surveyed during 2016. See the section on limiting factors for a more detailed description of non-algal turbidity and its application.

Waterbody	Chlorophyll-a (ug/L)	Secchi Disk Depth (cm)	Non-Algal Turbidity (m-1)	Euphotic to Mixed Depth Ratio
Concannon State Fishing Lake	1.21	>140	0.694	17.93
Otis Creek Lake[1]	3.31	NA	NA	N/A
New Alma City Lake	4.62	196	0.505	1.05
Xenia Lake	4.83	183	0.541	1.03
Ford County Lake	5.54	36	2.773	1.20
Alma City Lake	6.00	213	0.465	1.07
Wolf Creek Lake	6.36	142	0.700	0.60
Pleasanton Reservoir	7.65	200	0.497	1.30
Toronto Lake	9.40	22	4.543	0.55
Kiowa Co. State Fishing Lake	10.7	58	1.722	3.97
Lake Coldwater	13.2	106	0.941	1.41
Prairie Lake	16.1	71	1.407	1.01
Big Hill Lake	17.0	120	0.832	0.54
Elk City Lake	20.2	44	2.271	0.67
Horsethief Canyon Lake	20.5	101	0.989	0.74
Jewell Co. State Fishing Lake	25.5	143	0.698	1.16
Jetmore Lake	26.6	101	0.989	1.23
Gridley City Lake	27.1	55	1.817	1.83
Kirwin Lake	27.3	83	1.204	0.76
Atchison County Park Lake	27.9	37	2.702	6.52
Fall River Lake	28.1	43	2.325	0.77

Waterbody	Chlorophyll-a (ug/L)	Secchi Disk Depth (cm)	Non-Algal Turbidity (m-1)	Euphotic to Mixed Depth Ratio
Waconda Lake	28.2	100	0.999	0.52
Lake Jewell	36.8	26	3.845	1.15
Scott State Fishing Lake	41.9	72	1.388	1.45
Norton Lake	52.4	58	1.724	0.65
Lovewell Lake	54.1	37	2.702	0.58
La Cygne Lake	56.1	72	1.388	0.53
Veteran's Lake	61.6	80	1.250	1.22
Antelope Lake	61.8	28	3.571	0.95
Hodgeman Co. State Fishing Lake	65.7	49	2.040	0.74
Crystal Lake	72.2	42	2.381	1.07
Central Park Lake	94.6	36	2.778	3.72
Jamestown Wildlife Area	130	10	10.000	48.32

[1] Otis Creek Lake was sampled from the elevated water intake structure and therefore Secchi depth was not able to be measured. Field observations indicate very good water clarity.

Fecal Indicator Bacteria

Since 1996, bacterial sampling has taken place at the primary water quality sampling station at each lake monitored by KDHE. For several years prior to 1996, sampling took place at swimming beaches or boat ramp access areas. Whereas many Kansas lakes have swimming beaches, many others do not. However, presence or absence of a swimming beach does not determine whether or not a lake supports primary contact recreational use. Primary contact recreation occurs when “a person is immersed to the extent that some inadvertent ingestion of water is probable.” Activities can include “boating, mussel harvesting, swimming, skin diving, waterskiing, and windsurfing.” (see K.A.R. 28-16-28d (7)(A); KDHE, 2015). The majority of Kansas lakes have some form of primary contact recreation taking place during the warmer months (April 1 – October 31) of the year. Also, sampling of swimming beaches is often conducted by lake managers to document water quality where people are concentrated in a small area on specific days. These managers are in the best position to collect samples frequently enough to determine compliance with applicable regulations at these swimming beaches (KDHE, 2015).

Given the rapid die-off of fecal bacteria in the aquatic environment, due to protozoan predation and a generally hostile set of environmental conditions, high bacterial counts should only occur in the open water of a lake if there has been 1) a recent pollution event, or 2) a chronic input of bacteria-laced pollution. For the purposes of this report, a single set of bacterial samples collected from the open, deep-water environment of the primary sampling location is considered representative of whole-lake bacterial water quality at the time of the survey. This environment is less prone to short-lived fluctuations in bacterial counts (expressed as most probable number of colonies, or “MPN”, in 100 mL of water) than are swimming beaches and other shoreline areas.

Table 9 presents the bacterial data collected during the 2016 sampling season. Sixteen of the 34 lakes and wetlands surveyed for *E. coli* bacteria in 2016 (47%) had measurable levels of *E. coli* (i.e., greater than the analytical reporting limit of 10 MPN/100mL) in at least one sample. None of the water bodies exceeded existing single-sample criteria (KDHE, 2015). The mean and median *E. coli* count among these 34 waterbodies (with non-detects set to half the detection limit) was 57 MPN/100mL and <10 MPN/100mL, respectively.

Table 9. *E. coli* counts (mean of duplicate samples with non-detects set to half the detection limit) from waterbodies surveyed for *E. coli* during 2016. Units are expressed as "Most Probable Number" of colonies in 100mL of lake water.

Waterbody	**Site Location**	***E. coli* Count**
Alma City Lake	open water	<10
Antelope Lake	open water	<10
Big Hill Lake	open water	<10
Concannon State Fishing Lake	open water	<10
Elk City Lake	open water	<10
Fall River Lake	open water	<10
Gridley City Lake	open water	<10
Horsethief Canyon Lake	open water	<10
Kiowa Co. State Fishing Lake	open water	<10
Kirwin Lake	open water	<10
La Cygne Lake	open water	<10
Lake Coldwater	open water	<10
Lovewell Lake	open water	<10
New Alma City Lake	open water	<10
Norton Lake	open water	<10
Otis Creek Lake	off pier near dam	<10
Pleasanton Reservoir	open water	<10
Scott State Fishing Lake	open water	<10
Toronto Lake	open water	<10
Waconda Lake	open water	<10
Wolf Creek Lake	open water	<10
Xenia Lake	open water	<10
Atchison Co. Park Lake	open water	10
Crystal Lake	open water	13
Veteran's Lake	open water	13
Hodgeman Co. State Fishing Lake	open water	15
Prairie Lake	open water	18
Ford Co. Lake	open water	26
Jetmore Lake	open water	31
Central Park Lake	open water	69
Jewell Co. State Fishing Lake	open water	80
Jamestown Wildlife Area	shore	452
Big Spring	shore	471
Lake Jewell	open water	805

Limiting Nutrients and Physical Parameters

The determination of which nutrient, or physical characteristic, "limits" phytoplankton production is of primary importance in lake management. If certain features can be shown to exert exceptional influence on lake water quality, those features can be addressed in lake protection plans to a greater degree than less important factors. In this way, lake management can be made more efficient.

Common factors that limit algal production in lakes are the level of available nutrients (phosphorus and nitrogen, primarily) and the amount of light available in the water column for photosynthesis. Less common limiting factors in lakes, and other lentic water bodies, include available levels of carbon, iron, and certain trace elements (such as molybdenum or vanadium), as well as grazing pressure on the phytoplankton community, competition from macrophytes and/or periphyton, water temperature, and hydrologic flushing rate.

Nutrient ratios are commonly considered in determining which major plant nutrients are limiting factors in lakes. These ratios take into account the relative needs of algae for the different chemical elements versus availability in the environment. Typically, total nitrogen/total phosphorus (TN/TP) mass ratios above 12 indicate increasing phosphorus limitation, with phosphorus limitation fairly certain at ratios above 18. Conversely, TN/TP ratios of less than 10 indicate increasing importance of nitrogen. Ratios of 10-to-12 generally indicate that both nutrients, or neither, may limit algal production (Wetzel, 1983; Horne and Goldman, 1994). It should also be kept in mind, when evaluating limiting factors, that very turbid lakes typically have lower nutrient ratios (due to elevation of phosphorus concentration, relative to nitrogen, in suspended clay particles) but may still experience phosphorus limitation due to biological availability (e.g., particle adsorption) issues (Jones and Knowlton, 1993).

In addition to nutrient ratios, the following six metrics (see Table 10a) are applied in determining the relative roles of light and nutrient limitation for lakes in Kansas (see Walker, 1986; Scheffer, 1998).

Table 10a. Criteria used to classify lakes based on the various metrics applied in this report (see Walker, 1986; Scheffer, 1998).

Expected Lake Condition	**TN/TP**	**NAT**	**Z_{mix}*NAT**	**Chl-a*SD**	**Chl-a/TP**	**Z_{mix}/SD**	**Shading**
Phosphorus Limiting	>12				>0.40		
Nitrogen Limiting	<7				<0.13		
Light/Flushing Limited		>1.0	>6	<6	<0.13	>6	>16
High Algae-to-Nutrient Response		<0.4	<3	>16	>0.40	<3	
Low Algae-to-Nutrient Response		>1.0	>6	<6	<0.13	>6	
High Inorganic Turbidity		>1.0	>6	<6		>6	>16
Low Inorganic Turbidity		<0.4	<3	>16		<3	<16
High Light Availability			<3	>16		<3	<16
Low Light Availability			>6	<6		>6	>16

1) Non-Algal Turbidity = (1/SD)-(0.025m^2/mg*C),

where SD = Secchi depth in meters and C = chlorophyll-a in mg/m^3.

Non-algal turbidity values <0.4 m^{-1} tend to indicate very low levels of suspended silt and/or clay, whereas values >1.0 m^{-1} indicate that inorganic particles are important in creating turbidity. Values between 0.4 and 1.0 m^{-1} describe a range where inorganic turbidity assumes a progressively greater influence on water clarity. However, this parameter normally would assume a significant limiting role only if values exceeded 1.0 m^{-1}.

2) Light Availability in the Mixed Layer = Z_{mix}*Non-Algal Turbidity,

where Z_{mix} = depth of the mixed layer, in meters.

Values <3 indicate abundant light within the mixed layer of a lake and a high potential response by algae to nutrient inputs. Values >6 indicate the opposite.

3) Partitioning of Light Extinction Between Algae and Non-Algal Turbidity = Chl-a*SD,

where Chl-a = chlorophyll-a in mg/m^3 and SD = Secchi depth in meters.

Values <6 indicate that inorganic turbidity is primarily responsible for light extinction in the water column and there is a weak algal response to changes in nutrient levels. Values >16 indicate the opposite.

4) Algal Use of Phosphorus Supply = Chl-a/TP,

where Chl-a = chlorophyll-a in mg/m^3 and TP = total phosphorus in mg/m3 .

Values <0.13 indicate a limited response by algae to phosphorus (i.e., nitrogen, light, or other factors may be more important). Values above 0.4 indicate a strong algal response to changes in phosphorus level. The range 0.13-to-0.40 suggests a variable but moderate response by algae to fluctuating phosphorus levels.

5) Light Availability in the Mixed Layer for a Given Surface Light = Z_{mix}/SD,

where Z_{mix} = depth of the mixed layer, in meters, and SD = Secchi depth in meters.

Values <3 indicate that light availability is high in the mixed zone and the probability of strong algal responses to changes in nutrient levels is high. Values >6 indicate the opposite.

6) Shading in Water Column due to Algae and Inorganic Turbidity = Z_{mean}*E,

where Z_{mean} = mean lake depth, in meters, and E = calculated light attenuation coefficient, in units of m^{-1}, derived from Secchi depth and chlorophyll-a data (Scheffer, 1998).

Values >16 indicate high levels of self-shading due to algae or inorganic turbidity in the water column. Values <16 indicate that self-shading of algae does not significantly impede productivity. The metric is most applicable to lakes with maximum depths of less than 5 meters (Scheffer, 1998).

Table 10b presents limiting factor determinations for the lakes surveyed during 2016. These determinations reflect the time of sampling (chosen to reflect average conditions during the summer growing season, sometimes called the “critical period” in lake water quality assessment, to the extent possible) and may be less applicable to other times of the year. Conditions during one survey may also differ significantly from conditions during past surveys, despite efforts to sample during representative summer weather conditions. If such a situation is suspected, it is noted in **Table 10** or elsewhere in this report.

Table 10b. Limiting factor determinations for the 34 lakes and wetlands surveyed during 2016. NAT = non-algal turbidity, TN/TP = nitrogen-to-phosphorus ratio, Z_{mix} = depth of mixed layer, Chl-a = chlorophyll-a, and SD = Secchi depth. N = nitrogen, P = phosphorus, C = carbon, L = light, and ? = unknown. Shading = calculated light attenuation coefficient times mean lake depth.

Waterbody	TN/TP	NAT	Zmix*NAT	Chl-a*SD	Chl-a/TP	Zmix/SD	Shading	Factors
Alma City Lake	14.5	0.47	1.8	12.78	0.3	1.82	4.49	P
Antelope Lake	8.37	3.57	5.09	17.3	0.29	5.09	5.06	L
Atchison Co. Park Lake	11.75	2.7	0.77	10.34	0.1	0.77	1.2	L>P
Big Hill Lake	9.46	0.83	4.88	20.4	0.1	4.89	10.91	?
Big Spring	365	N/A	N/A	N/A	N/A	N/A	N/A	P
Central Park Lake	6.31	2.78	0.97	34.06	0.29	0.97	1.95	N>L
Concannon SFL	10.91	0.69	0.16	1.7	0.01	0.16	0.48	Plants>N=P
Crystal Lake	21.47	2.38	3.39	30.34	0.82	3.39	4.5	P>L
Elk City Lake	9.66	2.27	7.28	8.89	0.23	7.29	6.95	L
Fall River Lake	10.2	2.32	6.08	12.06	0.41	6.08	5.97	L
Ford Co. Lake	1.64	2.77	4.94	2	0	4.95	3.87	N>L
Gridley City Lake	16.42	1.82	2.23	14.88	0.57	2.23	2.7	P
Hodgeman Co. SFL	2.7	2.04	4.57	32.18	0.07	4.57	6.15	N>L
Horsethief Canyon Lake	25.45	0.99	3.91	20.73	0.41	3.92	6.55	P
Jamestown Wildlife Area	6.9	10	0.13	13.05	0.29	0.13	0.75	N
Jetmore Lake	3.47	0.99	2.21	26.82	0.07	2.22	3.71	N
Jewell Co. SFL	16.33	0.7	1.83	36.5	0.35	1.83	3.96	P
Kiowa Co. SFL	48.97	1.72	1.14	6.2	0.37	1.14	1.46	P
Kirwin Lake	11.86	1.2	4.08	22.67	0.3	4.08	6.12	Flushing>P
La Cygne Lake	28.11	1.39	5.23	40.36	1.52	5.23	9.05	P
Lake Coldwater	31.22	0.94	2.14	13.95	0.54	2.14	3.24	P
Lake Jewell	3.65	3.85	4.92	9.56	0.05	4.92	4.25	N>L
Lovewell Lake	4.38	2.7	7.4	20.02	0.21	7.4	7.85	N
New Alma City Lake	16.5	0.5	2.01	9.05	0.23	2.03	4.62	P
Norton Lake	10.33	1.72	5.06	30.38	0.35	5.07	7.07	Flushing>P
Otis Creek Lake	12.5	N/A	N/A	N/A	0.17	N/A	N/A	?
Pleasanton Reservoir	23.49	0.5	1.54	15.3	0.36	1.55	3.57	P
Prairie Lake	23.54	1.41	3.81	11.41	0.41	3.81	4.56	P
Scott SFL	13.5	1.39	2.11	30.17	0.59	2.11	3.28	P
Toronto Lake	7.57	4.54	12.63	2.07	0.07	12.63	8.33	L
Veteran's Lake	17.61	1.25	2.01	49.24	0.87	2.01	3.86	P
Waconda Lake	13.93	1	5.16	28.23	0.39	5.16	10.31	P
Wolf Creek Lake	34.25	0.7	4.41	9.02	0.32	4.43	10.54	P
Xenia Lake	36	0.54	2.15	8.84	0.24	2.17	4.7	P

Seventeen lakes (50.0%) were determined to be primarily phosphorus limited whereas seven of the 34 waterbodies (20.6%) were determined to be primarily limited by nitrogen. Five lakes were primarily light limited in the 2016 season (14.7%). Two lakes (5.9%) were limited by hydrologic flushing due to high amounts of precipitation and runoff during the spring and early summer. One lake was limited by abundant macrophyte growth and limiting factors for two lakes were unable to be resolved. Interquartile ranges for TN/TP ratios were 16.4-to-31.2 for phosphorus limited lakes and 3.1-to-5.3 for nitrogen limited lakes.

Pesticides in Kansas Lakes

Detectable levels of at least one pesticide were documented in 27 of the waterbodies sampled in 2016 (79.4% of lakes and wetlands surveyed for pesticides). Table 11 lists these lakes and the pesticides that were detected, along with the level measured and the analytical quantification limit. Six different pesticides were noted in 2016. Of these compounds, alachlor, atrazine, metribuzin, and simazine currently have numeric criteria in place for aquatic life support and/or water supply uses (KDHE, 2015).

Atrazine continues to be the pesticide detected most often in Kansas lakes (KDHE, 1991) accounting for 81% of the total number of pesticide detections in waterbodies sampled during 2016. Additionally, 13 lakes had detectable levels of metolachlor (Dual), four lakes had detectable levels of acetochlor (Harness or Surpass), and metribuzin (Sencor), prometon (Pramitol), and simazine (Princep) were detected at one lake each.

In all cases, the presence of these pesticides was directly attributable to agricultural activity, although prometon is often used in conjunction with brush control in parks and urban areas or around construction sites. Atrazine levels in two lakes surveyed in 2016 exceeded 3.0 ug/L (Hodgeman Co. SFL and Jetmore Lake). Three lakes had detectable levels of more than two pesticides (Atchison Co. Park Lake, Lake Jewell, and Veteran's Lake).

Table 11. Pesticide levels documented during 2016 in Kansas lakes and wetlands. All values listed are in ug/L and analytical quantification limits are given in parentheses. Only those waterbodies with detectable levels of pesticides are listed and blank cells indicate non-detection.

Waterbody	**Acetochlor (0.10)**	**Atrazine (0.30)**	**Metolachlor (0.25)**	**Metribuzin (0.10)**	**Prometon (0.20)**	**Simazine (0.30)**
Antelope Lake		1.7				
Atchison Co. Park Lake	4.7	1	11			
Big Hill Lake		0.63				
Concannon State Fishing Lake		1.5	0.81			
Elk City Lake			0.28			
Fall River Lake			0.29			
Ford Co. Lake		1.7	0.31			
Gridley City Lake		0.77			0.82	
Hodgeman Co. State Fishing Lake	0.39	10				
Horsethief Canyon Lake		2	0.54			
Jamestown Wildlife Area				0.11		
Jetmore Lake		5.6	0.33			
Jewell Co. State Fishing Lake		0.32				
Kiowa Co. State Fishing Lake			0.53			
Kirwin Lake		0.85				
La Cygne Lake		0.68				
Lake Coldwater		0.64				

Waterbody	Acetochlor (0.10)	Atrazine (0.30)	Metolachlor (0.25)	Metribuzin (0.10)	Prometon (0.20)	Simazine (0.30)
Lake Jewell	0.14	0.49	0.39			
Lovewell Lake		0.91				
Norton Lake		0.56				
Pleasanton Reservoir	0.19	1.6				
Prairie Lake		1.6				
Toronto Lake			0.68			
Veteran's Lake		1.5	0.70			1.1
Waconda Lake		1.3	0.33			
Wolf Creek Lake		0.84	0.30			
Xenia Lake		1.3				

Exceedances of State Surface Water Quality Criteria

Most numeric and narrative water quality criteria referred to in this section are taken from the Kansas Administrative Regulations (K.A.R. 28-16-28b through K.A.R. 28-16-28f) (KDHE, 2015) or from EPA water quality criteria guidance documents (EPA, 1972, 1976) for ambient waters and finished drinking water. Copies of the Kansas regulations may be obtained from the Bureau of Water, KDHE, 1000 SW Jackson Street, Suite 420, Topeka, Kansas 66612.

Exceedances of surface water quality criteria and guidelines during the 2016 sampling season were documented by computerized comparison of the 2016 Lake and Wetland Monitoring Program data to the state surface water quality standards and applicable federal guidelines. Only those samples collected from a depth of <3.0 meters were used to document standards violations, as a majority of samples collected from below 3.0 meters were from hypolimnetic waters. In Kansas, lake hypolimnions generally constitute a small percentage of total lake volume. Although hypolimnetic waters usually have more pollutants present in measurable quantities, compared to overlying waters, they do not generally pose a significant water quality problem for the lake as a whole.

Criteria for eutrophication and turbidity in the Kansas standards are narrative rather than numeric for the vast majority of Kansas lakes and wetlands. However, lake trophic state does exert a documented impact on various lake uses, as does inorganic turbidity. The system shown in Table 12 has been developed over the last twenty plus years to define how lake trophic status influences the various designated uses of Kansas lakes (EPA, 1990; NALMS, 1992). Trophic state/use support expectations are compared with the observed trophic state conditions to determine the level of use support at each lake. The report appendix from the 2002 annual program report presents a comparison of these trophic class-based assessments, as well as turbidity-based assessments, versus statistically derived risk-based values (KDHE, 2002b). In general, the risk-based thresholds are comparable to those of the assessment system currently employed by KDHE. Exceptions to narrative eutrophication standards are the 82 lakes serving as active or reserve domestic water supply sources, which have a chlorophyll-*a* standard set to "the lesser value of 10 µg/L or long-term average" (KDHE, 2015; see Table 1k and Table 1l).

Table 12. Lake use support determination based on lake trophic state. A = argillotrophic (high turbidity lake); M = mesotrophic, TSI = zero-to-49.9; SE = slightly eutrophic, TSI = 50-to-54.9; E = eutrophic (fully eutrophic), TSI = 55-to-59.9; VE = very eutrophic, TSI = 60-to-63.9; H = hypereutrophic, TSI > 64; BG = blue-green algae dominate the community (50%+ as cell count and/or 33%+ as biovolume) X = use support assessment based on nutrient load and water clarity, not algal biomass

Designated Use	**A**	**M**	**SE**	**E**	**VE**	**H-no BG TSI 64-70**	**H-no BG TSI 70+**	**H-with BG TSI 64+**
Aquatic Life Support	X	Full	Full	Full	Partial	Partial	Non	Non
Domestic Water Supply	X	Full	Full	Partial	Partial	Non	Non	Non
Primary Contact Recreation	X	Full	Full	Partial	Partial	Non	Non	Non
Secondary Contact Recreation	X	Full	Full	Full	Partial	Partial	Non	Non
Livestock Water Supply	X	Full	Full	Full	Partial	Partial	Non	Non
Irrigation	X	Full	Full	Full	Partial	Partial	Non	Non
Groundwater Recharge	Trophic state is not generally applicable to this use.							
Food Procurement	Trophic state is applicable to this use, but not directly.							

Eutrophication exceedances are primarily due to excessive nutrient inputs from lake watersheds. Dissolved oxygen problems are generally due to advanced trophic state, which causes rapid oxygen depletion below the thermocline. Lakes with elevated pH also are reflective of high trophic state and algal and/or macrophytic production. In 2016, 23 lakes (70%) had trophic state conditions elevated enough to impair one or more uses. Twenty lakes (61%) had trophic state conditions elevated enough to cause moderate-to-severe impairments in a majority of uses.

Eight lakes had aquatic life use violations resulting from low dissolved oxygen levels in the epilimnion (Jewell Co. SFL, Fall River Lake, Toronto Lake, Gridley City Lake, Lake Jewell, Crystal Lake, Antelope Lake, and Ford County Lake). Concannon State Fishing Lake was impaired for aquatic life due to elevated pH levels resulting from the abundant macrophyte growth. These impairments were considered secondary responses to elevated trophic state and, in regard to dissolved oxygen, some exceptionally high late summer temperatures. Additionally, in four lakes (Antelope Lake, Atchison Co. Park Lake, Fall River Lake, and Toronto Lake) high inorganic turbidity levels were sufficient to impair primary and secondary recreational uses.

Atrazine >3.0 ug/L was documented in two lakes (Hodgeman Co. SFL and Jetmore Lake). For the second year in a row Pleasanton Reservoir had aquatic life violations for heavy metals including cadmium, lead, and silver during 2016 and mercury during 2015. Ford County Lake had aquatic life violations for lead. Salinity related parameters and other inorganic compounds were few, constituting only 4.0% of total criteria exceedances combined.

Conclusions

The following observations are based on lake monitoring data collected during 2016.

1) A lack of data for many of the smaller lakes on the Kansas Surface Water Register led to a hierarchical ranking procedure of lakes and wetlands in an effort to increase the number of classified waterbodies included in regular monitoring activities.

2) Trophic state data indicated that about 13% of the lakes surveyed in 2016 had degraded water quality in comparison to historic mean conditions (i.e., their trophic state had increased). About 74% showed stable conditions over time whereas another 13% exhibited improved trophic state conditions.

3) The presence of a macrophyte community generally improved the overall condition and functioning of a waterbody. Many of the higher quality lakes had an abundant and diverse macrophyte community.

4) A majority (79%) of the lakes surveyed in 2016 had detectable levels of agricultural pesticides. As noted in previous years, atrazine was the most frequently detected pesticide.

5) Most of the documented water quality impairments in lakes resulted from nutrient enrichment and elevated trophic state. Heavy metals and pesticides accounted for a small proportion of the documented water quality criteria exceedances.

6) Phosphorus was found to be the limiting nutrient in half of the lakes sampled. Thus, maintaining or reducing phosphorus inputs could aid in improving trophic conditions in many systems.

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APPENDIX A: CATEGORIZATION AND RANKING OF CLASSIFIED WATERBODIES

In an effort to incorporate a larger percentage of classified waterbodies into the regular monitoring network, all 358 lakes and wetlands on the Kansas Surface Water Register were subjected to a hierarchical ranking procedure during 2015 and 2016. **Table A.1** shows the initial categorization for all 358 classified waterbodies (plus two, Big Spring and Black Kettle SFL, slated for inclusion in the register). However, the ranking of sites will undoubtedly be an ongoing, iterative process and sampling frequency and prioritization will be refined as sites are visited and more contemporary observations become available.

The highest priority lakes are the 24 federal reservoirs (“FED”) in Kansas. These large impoundments serve multiple purposes (e.g., flood control, recreation, domestic water supply, irrigation) and draw a large number of users throughout the year. Federal reservoirs are sampled on a three-year rotation (i.e. blocks of eight every three years). Another important group of lakes are those acting as domestic water supplies (“PWS”). KDHE’s Public Water Supply Section lists 39 classified waterbodies (13 of which are federal reservoirs) as being permanent domestic water supply sources. Because of the potential for the water quality of these lakes to affect a large number of users, the 26 additional lakes are scheduled for monitoring every three years. The final group of waterbodies on a three-year monitoring rotation are ten of Kansas’ most prominent wetland resources (“WET”). These areas, including some National Wildlife Refuges, are given a high priority due to their ecological significance and relative rarity across the state.

The second tier of classified waterbodies are the State Fishing Lakes (“SFL”) owned and operated by the Department of Wildlife, Parks and Tourism. State owned properties experience high levels of recreational use and often represent some of the best publicly accessible waters in an area. These 46 lakes (and Big Spring) are scheduled for monitoring on a four-year rotation. However, if it is determined that a waterbody is prone to drying or does not provide suitable boating access (leading to potentially decreased usage) the lake can be downgraded to a lower priority. All SFLs should have a confirmed ranking by the end of one full cycle of visits (2018).

Thus far, 107 of the 360 classified waterbodies are prioritized. The remaining 253 are divided among three distinct categories: 1) Waterbodies scheduled for monitoring on a six-year rotation (“ALL”; n = 77), 2) Waterbodies scheduled for a reduced assessment consisting of only nutrient and chlorophyll-a analysis (“CHL”; n = 113), and 3) Waterbodies excluded from monitoring activities (“NO”; n = 63).

Many of the lakes scheduled for monitoring at a six-year interval are waterbodies that may serve as emergency or reserve domestic water supplies. Others in this category include the larger and more heavily used county and city lakes. Intermittent or very small systems are assessed using nutrient and chlorophyll-a data only. In doing so, up to 15-20 more lakes per year will receive an assessment without overburdening the Kansas Health and Environment Laboratory with extreme numbers of samples. Most of the waterbodies excluded from assessment are Mined Land Lakes (n=37) which are overrepresented in the register (seven Mined Land Lakes are assessed as a representative sample for the region). Other excluded waterbodies are dry most of the year, are privately owned, or are waterbodies listed on the register that are not true lentic systems (e.g., Pillsbury Crossing, Rocky Ford).

Table A.1. Initial classification and ranking of all classified lakes and wetlands. See Appendix A for explanation of Group codes.

Station	Waterbody	Group	Tier	Latitude	Longitude	County	HUC 8
LM010001	Norton Lake	FED1	1	39.80300	-99.93400	Norton	Prairie Dog
LM011001	Kirwin Lake	FED1	1	39.66200	-99.13200	Phillips	Upper North Fork Solomon
LM015001	Lovewell Lake	FED1	1	39.89100	-98.03200	Jewell	Middle Republican
LM018001	Waconda Lake	FED1	1	39.48700	-98.32700	Mitchell	Solomon
LM023001	Fall River Lake	FED1	1	37.65300	-96.06500	Greenwood	Fall
LM024001	Toronto Lake	FED1	1	37.74400	-95.92600	Woodson	Upper Verdigris
LM025001	Elk City Lake	FED1	1	37.27500	-95.78800	Montgomery	Elk
LM031001	Big Hill Lake	FED1	1	37.27100	-95.46600	Labette	Middle Verdigris
LM017001	Cheney Lake	FED2	1	37.72900	-97.80300	Reno	North Fork Ninnescah
LM020001	Marion Lake	FED2	1	38.37100	-97.08700	Marion	Upper Cottonwood
LM022001	Council Grove Lake	FED2	1	38.68400	-96.50400	Morris	Neosho Headwaters
LM026001	John Redmond Lake	FED2	1	38.23800	-95.77400	Coffey	Neosho Headwaters
LM027001	Melvern Lake	FED2	1	38.50900	-95.71200	Osage	Upper Marais Des Cygnes
LM028001	Pomona Lake	FED2	1	38.65300	-95.56100	Osage	Upper Marais Des Cygnes
LM033001	El Dorado Lake	FED2	1	37.84600	-96.81300	Butler	Upper Walnut River
LM035001	Hillsdale Lake	FED2	1	38.65900	-94.90500	Miami	Lower Marais Des Cygnes
LM012001	Webster Lake	FED3	1	39.40300	-99.42700	Rooks	Upper South Fork Solomon
LM013001	Cedar Bluff Lake	FED3	1	38.78600	-99.72700	Trego	Upper Smoky Hill
LM014001	Wilson Lake	FED3	1	38.96400	-98.49500	Russell	Upper Saline
LM016001	Kanopolis Lake	FED3	1	38.61700	-97.97400	Ellsworth	Middle Smoky Hill
LM019001	Milford Lake	FED3	1	39.08100	-96.90300	Geary	Lower Republican
LM021001	Tuttle Creek Lake	FED3	1	39.26000	-96.59600	Riley	Lower Big Blue
LM029001	Perry Lake	FED3	1	39.11900	-95.42700	Jefferson	Delaware
LM030001	Clinton Lake	FED3	1	38.92100	-95.33800	Douglas	Lower Kansas
LM044201	Pleasanton Reservoir	PWS1	1	38.19600	-94.68900	Linn	Lower Marais Des Cygnes
LM048701	Murray Gill Lake	PWS1	1	37.23400	-96.18100	Chautauqua	Caney
LM049901	New Alma City Lake	PWS1	1	38.97600	-96.29800	Wabaunsee	Middle Kansas
LM050001	Alma City Lake	PWS1	1	38.97900	-96.26200	Wabaunsee	Middle Kansas
LM053901	Otis Creek Lake	PWS1	1	37.92900	-96.46400	Greenwood	Fall

Station	Waterbody	Group	Tier	Latitude	Longitude	County	HUC 8
LM061901	Prairie Lake	PWS1	1	39.48700	-95.68800	Jackson	Middle Kansas
LM074401	Xenia Lake	PWS1	1	37.97138	-94.98389	Bourbon	Middle Kansas
LM012701	Polk Daniels State Fishing Lake	PWS2	1	37.46100	-96.22700	Elk	Elk
LM032001	Banner Creek Lake	PWS2	1	39.45600	-95.76600	Jackson	Delaware
LM042001	Lake Wabaunsee	PWS2	1	38.86600	-96.19600	Wabaunsee	Middle Kansas
LM042301	Wellington New City Lake	PWS2	1	37.20400	-97.52700	Sumner	Chikaskia
LM043001	Council Grove City Lake	PWS2	1	38.67700	-96.55500	Morris	Neosho Headwaters
LM046801	Richmond City Lake	PWS2	1	38.39300	-95.22300	Franklin	Upper Marais Des Cygnes
LM047201	Herington Reservoir	PWS2	1	38.66200	-97.00800	Dickinson	Lower Smoky Hill
LM050801	Winfield City Lake	PWS2	1	37.35300	-96.89200	Cowley	Lower Walnut River
LM073001	Pony Creek Lake	PWS2	1	39.94700	-95.77700	Brown	Lower Marais Des Cygnes
LM040001	Augusta City Lake	PWS3	1	37.69900	-96.98200	Butler	Upper Walnut River
LM041601	Augusta Santa Fe Lake	PWS3	1	37.70500	-97.04900	Butler	Upper Walnut River
LM043901	Bone Creek Lake	PWS3	1	37.62400	-94.73700	Crawford	Marmaton
LM044301	Linn Valley Lake	PWS3	1	38.37800	-94.72400	Miami	Lower Marais Des Cygnes
LM044401	Chanute Santa Fe Lake	PWS3	1	37.65700	-95.45400	Neosho	Upper Neosho
LM051201	Strowbridge Reservoir	PWS3	1	38.81700	-95.64100	Osage	Lower Kansas
LM051301	Critzer Lake	PWS3	1	38.14800	-94.92600	Linn	Lower Marais Des Cygnes
LM051801	Madison City Lake	PWS3	1	38.10700	-96.14700	Greenwood	Upper Verdigris
LM053801	New Yates Center Lake	PWS3	1	37.83400	-95.80300	Woodson	Upper Verdigris
LM072101	Severy City Lake	PWS3	1	37.62140	-96.17330	Greenwood	Lower Walnut River
LM052801	Jamestown Wildlife Area	WET1	1	39.64100	-97.89700	Cloud	Lower Republican
LM053201	Marais Des Cygnes Wildlife Area	WET1	1	38.28100	-94.73400	Linn	Lower Marais Des Cygnes
LM072401	Flint Hills Nwr	WET1	1	38.33800	-95.95100	Coffey	Caney
LM014201	Slate Creek Wildlife Area Wetland	WET2	1	37.17600	-97.19800	Sumner	Middle Arkansas-Slate
LM014701	Mcpherson Wetlands	WET2	1	38.40200	-97.75000	McPherson	Little Arkansas
LM050201	Quivera Little Salt Marsh	WET2	1	38.10300	-98.48600	Stafford	Rattlesnake
LM050601	Quivera Big Salt Marsh	WET2	1	38.18300	-98.53000	Stafford	Rattlesnake
LM014401	Baker Wetlands	WET3	1	38.92100	-95.23300	Douglas	Lower Kansas
LM050401	Cheyenne Bottoms Pool #1	WET3	1	38.45300	-98.64100	Barton	Cow

Station	Waterbody	Group	Tier	Latitude	Longitude	County	HUC 8
LM053401	Neosho Wildlife Area	WET3	1	37.48800	-95.12500	Neosho	Middle Neosho
LM011201	Scott State Fishing Lake	SFL1	2	38.69100	-100.92400	Scott	Ladder Kansas.
LM011231	Big Spring	SFL1	2	38.66713	-100.91975	Scott	Ladder Kansas.
LM016101	Hamilton Co. State Fishing Lake	SFL1	2	38.02900	-101.82000	Hamilton	Middle Arkansas-Lake McKinney
LM042801	Kiowa Co. State Fishing Lake	SFL1	2	37.61200	-99.30100	Kiowa	Rattlesnake
LM052401	Goodman State Fishing Lake	SFL1	2	38.38600	-99.85200	Ness	Lower Walnut Creek
LM053601	Concannon State Fishing Lake	SFL1	2	38.07000	-100.56300	Finney	Pawnee
LM070201	Sherman Co. State Fishing Lake	SFL1	2	39.18480	-101.78300	Sherman	Upper Smoky Hill
LM070401	Logan Co. State Fishing Lake	SFL1	2	38.93530	-101.23900	Logan	Lower Smoky Hill
LM070701	Finney Co. State Fishing Lake	SFL1	2	38.17500	-100.33200	Finney	Buckner
LM070801	Ford County Lake	SFL1	2	37.82500	-99.91810	Ford	Middle Arkansas-Lake McKinney
LM070901	Hain State Fishing Lake	SFL1	2	37.85400	-99.85800	Ford	Arkansas-Dodge City
LM074201	Hodgeman Co. State Fishing Lake	SFL1	2	38.04800	-99.82500	Hodgeman	Middle Kansas
LM010201	Chase Co. State Fishing Lake	SFL2	2	38.37000	-96.58200	Chase	Lower Cottonwood
LM010301	Brown Co. State Fishing Lake	SFL2	2	39.84500	-95.37600	Brown	Tarkio-Wolf
LM010401	Kingman Co. State Fishing Lake	SFL2	2	37.65000	-98.25500	Kingman	South Fork Ninnescah
LM010901	Washington Co. State Fishing Lake	SFL2	2	39.92400	-97.11700	Washington	Lower Little Blue
LM011301	Douglas Co. State Fishing Lake	SFL2	2	38.80400	-95.15800	Douglas	Lower Kansas
LM012401	Osage Co. State Fishing Lake	SFL2	2	38.76300	-95.67300	Osage	Upper Marais Des Cygnes
LM012601	Atchison Co. State Fishing Lake	SFL2	2	39.63600	-95.17200	Atchison	Independence-Sugar
LM013301	Bourbon Co. State Fishing Lake	SFL2	2	37.79700	-95.06500	Bourbon	Marmaton
LM013701	Saline Co. State Fishing Lake	SFL2	2	38.90200	-97.65500	Saline	Lower Saline
LM052101	Black Kettle State Fishing Lake	SFL2	2	38.23000	-97.51100	#N/A	Little Arkansas
LM061501	Nebo Watershed Lake	SFL2	2	39.44700	-95.59700	Jackson	Delaware
LM010801	Nemaha Co. State Fishing Lake	SFL3	2	39.76800	-96.02900	Nemaha	South Fork Big Nemaha
LM011101	Lake Crawford	SFL3	2	37.64400	-94.80900	Crawford	Marmaton
LM011801	Woodson Co. State Fishing Lake	SFL3	2	37.78900	-95.84300	Woodson	Upper Verdigris
LM011901	Rooks Co. State Fishing Lake	SFL3	2	39.40200	-99.31900	Rooks	Lower South Fork Solomon
LM012301	Leavenworth Co. State Fishing Lake	SFL3	2	39.12300	-95.15300	Leavenworth	Lower Kansas
LM012901	Pottawatomie State Fishing Lake #1	SFL3	2	39.46900	-96.40800	Pottawatomie	Middle Kansas

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LM013201	Pottawatomie State Fishing Lake #2	SFL3	2	39.22900	-96.52600	Pottawatomie	Lower Big Blue
LM015101	Wilson Co. State Fishing Lake	SFL3	2	37.69300	-95.67700	Wilson	Upper Verdigris
LM043201	Geary Co. State Fishing Lake	SFL3	2	38.90400	-96.86500	Geary	Lower Smoky Hill
LM043601	Miami Co. State Fishing Lake	SFL3	2	38.42000	-94.79300	Miami	Lower Marais Des Cygnes
LM043801	Louisburg State Fishing Lake	SFL3	2	38.50400	-94.68500	Miami	Lower Marais Des Cygnes
LM069401	Sheridan Co. State Fishing Lake	SFL3	2	39.35900	-100.22800	Sheridan	Big
LM010101	Clark Co. State Fishing Lake	SFL4	2	37.38300	-99.78200	Clark	Upper Cimarron-Bluff
LM010501	Lyon Co. State Fishing Lake	SFL4	2	38.54600	-96.05800	Lyon	Upper Marais Des Cygnes
LM010601	Meade Lake	SFL4	2	37.16400	-100.43200	Meade	Crooked
LM010701	Montgomery Co. State Fishing Lake	SFL4	2	37.16200	-95.68700	Montgomery	Middle Verdigris
LM012501	Shawnee Co. State Fishing Lake	SFL4	2	39.20100	-95.80400	Shawnee	Middle Kansas
LM012801	Jewell Co. State Fishing Lake	SFL4	2	39.69800	-98.28100	Jewell	Solomon
LM013101	Barber Co. State Fishing Lake	SFL4	2	37.29600	-98.58100	Barber	Medicine Lodge
LM013401	Cowley Co. State Fishing Lake	SFL4	2	37.09800	-96.80400	Cowley	Kaw Lake
LM013501	McPherson Co. State Fishing Lake	SFL4	2	38.48100	-97.46900	McPherson	Lower Smoky Hill
LM014101	Ottawa Co. State Fishing Lake	SFL4	2	39.10600	-97.57200	Ottawa	Solomon
LM044601	Neosho Co. State Fishing Lake	SFL4	2	37.42100	-95.19800	Neosho	Middle Neosho
LM049401	Butler Co. State Fishing Lake	SFL4	2	37.54800	-96.69400	Butler	Lower Walnut River
LM039601	Wolf Creek Lake	ALL1	3	38.19600	-95.68500	Coffey	Upper Neosho
LM042601	Lake Coldwater	ALL1	3	37.24500	-99.35000	Comanche	Upper Cimarron-Bluff
LM044002	La Cygne Lake	ALL1	3	38.34100	-94.65400	Linn	Lower Marais Des Cygnes
LM045601	Gridley City Lake	ALL1	3	38.11300	-95.87700	Coffey	Upper Neosho
LM055001	Horsethief Canyon Lake	ALL1	3	38.06200	-100.05200	Hodgeman	Buckner
LM060601	Atchison County Park Lake	ALL1	3	39.63600	-95.46000	Atchison	Lower Kansas
LM060901	Central Park Lake	ALL1	3	39.03900	-95.69100	Shawnee	Middle Kansas
LM062901	Lake Jewell	ALL1	3	39.67200	-98.16100	Jewell	Little Arkansas
LM064901	Crystal Lake	ALL1	3	38.26800	-95.24500	Anderson	Lower Marais Des Cygnes
LM066201	Osawatomie City Lake	ALL1	3	38.52700	-94.99300	Miami	Lower Marais Des Cygnes
LM069501	Antelope Lake	ALL1	3	39.37400	-100.11100	Graham	Lower Smoky Hill
LM071501	Veteran's Lake	ALL1	3	38.37080	-98.79520	Barton	Middle Verdigris

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LM073901	Jetmore Lake	ALL1	3	38.05280	-99.95510	Hodgeman	Spring
LM011401	Lone Star Lake	ALL2	3	38.84000	-95.38000	Douglas	Lower Kansas
LM011601	Hiawatha City Lake	ALL2	3	39.82600	-95.52800	Brown	Tarkio-Wolf
LM013601	Mission Lake	ALL2	3	39.67300	-95.51700	Brown	Delaware
LM022601	Lenexa City Lake	ALL2	3	38.96600	-94.83700	Johnson	Lower Kansas
LM039801	Lake Warnock	ALL2	3	39.53900	-95.14900	Atchison	Independence-Sugar
LM040601	Garnett Lake	ALL2	3	38.30500	-95.24400	Anderson	Upper Marais Des Cygnes
LM045401	Bartlett City Lake	ALL2	3	37.05900	-95.21600	Labette	Middle Neosho
LM051401	Mound City Lake	ALL2	3	38.12800	-94.89100	Linn	Lower Marais Des Cygnes
LM061601	Cedar Lake	ALL2	3	38.84700	-94.84700	Johnson	Lower Kansas
LM065001	Edgerton City Lake	ALL2	3	38.76370	-95.00400	Johnson	Lower Kansas
LM070501	Rimrock Park Lake	ALL2	3	39.02140	-96.85010	Geary	Lower Smoky Hill
LM071901	Moline Reservoir	ALL2	3	37.38800	-96.31300	Elk	Fall
LM073401	Potter's Lake	ALL2	3	38.96030	-95.24880	Douglas	Lower Kansas
LM012101	Marion Co. Lake	ALL3	3	38.31600	-96.99100	Marion	Upper Cottonwood
LM039501	Jeffrey Energy Center North Lake	ALL3	3	39.26400	-96.13700	Pottawatomie	Middle Kansas
LM040401	Gardner Lake	ALL3	3	38.85300	-94.93300	Johnson	Lower Kansas
LM040701	Cedar Valley Lake	ALL3	3	38.25600	-95.31200	Anderson	Upper Marais Des Cygnes
LM046401	Blue Mound City Lake	ALL3	3	38.10500	-95.02700	Linn	Lower Marais Des Cygnes
LM048801	Anthony City Lake	ALL3	3	37.17400	-98.05200	Harper	Chikaskia
LM049001	Harvey Co. West Park Lake	ALL3	3	38.07400	-97.58500	Harvey	Little Arkansas
LM049201	Lake Afton	ALL3	3	37.60500	-97.62900	Sedgwick	Ninnescah
LM052601	Fossil Lake	ALL3	3	38.86100	-98.84800	Russell	Middle Smoky Hill
LM062201	Waterwork's Lake	ALL3	3	38.87500	-94.80500	Johnson	Lower Missouri-Crooked
LM069601	Ellis City Lake	ALL3	3	38.94000	-99.55400	Ellis	Lower Smoky Hill
LM071201	Atwood Township Lake	ALL3	3	39.81610	-101.04200	Rawlins	South Fork Republican
LM071301	Colby City Pond	ALL3	3	39.38200	-101.05300	Thomas	Lower Walnut Creek
LM011501	Sabetha City Lake	ALL4	3	39.90700	-95.90400	Nemaha	South Fork Big Nemaha
LM012201	Lake Shawnee	ALL4	3	39.01400	-95.62800	Shawnee	Middle Kansas
LM017501	Colwich City Lake	ALL4	3	37.78100	-97.52900	Sedgwick	Middle Arkansas-Slate

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LM022401	Riggs Park Lake	ALL4	3	37.56800	-97.36200	Sedgwick	Middle Arkansas-Slate
LM048601	Sedan City North Lake	ALL4	3	37.17000	-96.21800	Chautauqua	Caney
LM052001	Harvey Co. East Lake	ALL4	3	38.04700	-97.19900	Harvey	Upper Walnut River
LM064201	Newton City Park Lake	ALL4	3	38.04300	-97.35600	Harvey	Middle Arkansas-Slate
LM064601	Chisholm Creek Park Lake South	ALL4	3	37.74100	-97.26800	Sedgwick	Little Arkansas
LM064701	Mingenback Lake	ALL4	3	38.37300	-97.65100	McPherson	Cow
LM072001	Sedan City South Lake	ALL4	3	37.15100	-96.20800	Chautauqua	Upper Verdigris
LM072801	Herington City Park Lake	ALL4	3	38.67660	-96.94440	Dickinson	Big Nemaha
LM073701	Centralia Lake	ALL4	3	39.70570	-96.15630	Nemaha	Lower Big Blue
LM040201	Eureka Lake	ALL5	3	37.89800	-96.29100	Greenwood	Upper Verdigris
LM041001	Olpe City Lake	ALL5	3	38.25100	-96.18400	Lyon	Neosho Headwaters
LM042401	Wyandotte County Lake	ALL5	3	39.17000	-94.77300	Wyandotte	Independence-Sugar
LM044801	Elm Creek Lake	ALL5	3	37.76100	-94.85300	Bourbon	Marmaton
LM045201	Rock Creek Lake	ALL5	3	37.81600	-94.75400	Bourbon	Marmaton
LM050701	Buhler City Lake	ALL5	3	38.14100	-97.76900	Reno	Little Arkansas
LM051001	Miola Lake	ALL5	3	38.58500	-94.84300	Miami	Lower Marais Des Cygnes
LM060001	St. Jacobs Well	ALL5	3	37.24000	-99.98200	Clark	Upper Cimarron-Bluff
LM060301	Mallard Lake	ALL5	3	37.14500	-101.79300	Morton	Upper Cimarron
LM060401	Cimarron Lake	ALL5	3	37.13600	-101.82200	Morton	Delaware
LM060501	Point Of Rocks Lake	ALL5	3	37.11600	-101.91200	Morton	Lower Republican
LM063001	Carey Park Lake	ALL5	3	38.04800	-97.84000	Reno	Little Arkansas
LM064001	Pratt County Lake	ALL5	3	37.62980	-98.68130	Pratt	Little Arkansas
LM066101	Osage City Reservoir	ALL5	3	38.61780	-95.83290	Osage	Lower Marais Des Cygnes
LM035401	Mined Land Lake 4	ALL6	3	37.43900	-94.62500	Crawford	Spring
LM035901	Mined Land Lake 12	ALL6	3	37.25900	-94.81600	Cherokee	Middle Neosho
LM037301	Mined Land Lake 27	ALL6	3	37.20200	-95.04800	Cherokee	Middle Neosho
LM037601	Mined Land Lake 30	ALL6	3	37.22200	-95.02500	Cherokee	Middle Neosho
LM041401	Parsons Lake	ALL6	3	37.40200	-95.33400	Neosho	Middle Neosho
LM041801	Shawnee Mission Lake	ALL6	3	38.98300	-94.80900	Johnson	Lower Kansas
LM044101	Cedar Creek Reservoir	ALL6	3	37.82000	-94.79300	Bourbon	Marmaton

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LM045001	Fort Scott City Lake	ALL6	3	37.78800	-94.75700	Bourbon	Marmaton
LM047601	Mined Land Lake 6	ALL6	3	37.42200	-94.75400	Crawford	Spring
LM047801	Mined Land Lake 7	ALL6	3	37.39600	-94.77900	Crawford	Spring
LM048401	Mined Land Lake 44	ALL6	3	37.27000	-94.92400	Cherokee	Middle Neosho
LM061401	Mary's Lake	ALL6	3	38.92900	-95.21600	Douglas	Lower Kansas
LM010441	Kingman Co. SFL Wetland	CHL	4	37.65700	-98.26800	Kingman	South Fork Ninnescah
LM010941	Washington Co. SFL Wetland	CHL	4	39.93200	-97.12100	Washington	Lower Little Blue
LM011701	Ogden City Lake	CHL	4	39.10100	-96.70800	Riley	Upper Kansas
LM011841	Woodson Co. SFL Wetland	CHL	4	37.81100	-95.85300	Woodson	Upper Verdigris
LM014301	Isabel Wildlife Area Wetland	CHL	4	37.49400	-98.55500	Pratt	Chikaskia
LM014501	Sheridan Wildlife Area Wetland	CHL	4	39.13300	-100.18600	Sheridan	Upper Saline
LM020101	Cedar Crest Lake	CHL	4	39.06100	-95.74400	Shawnee	Middle Kansas
LM020401	Mahaffie Farmstead Lake	CHL	4	38.89300	-94.80400	Johnson	Lower Kansas
LM020501	Overbrook City Lake	CHL	4	38.78000	-95.54900	Osage	Lower Kansas
LM020701	Smith Lake	CHL	4	39.34600	-94.91800	Leavenworth	Independence-Sugar
LM020801	Merrit Lake	CHL	4	39.34800	-94.92000	Leavenworth	Independence-Sugar
LM020901	Hillsboro City Lake	CHL	4	38.34700	-97.20700	Marion	Upper Cottonwood
LM021101	Circle Lake	CHL	4	38.01900	-95.55500	Woodson	Upper Neosho
LM021301	Leonard's Lake	CHL	4	37.99300	-95.54100	Woodson	Upper Neosho
LM021401	Neosho Falls City Lake	CHL	4	38.00400	-95.55400	Woodson	Upper Neosho
LM021501	Harmon Wildlife Area Lake	CHL	4	37.06700	-95.07900	Labette	Middle Neosho
LM022101	Eagle Park Lake	CHL	4	37.76000	-97.27500	Sedgwick	Middle Arkansas-Slate
LM022201	Buffalo Park Lake	CHL	4	37.68800	-97.46100	Sedgwick	Middle Arkansas-Slate
LM022301	Harrison Park Lake	CHL	4	37.66900	-97.22200	Sedgwick	Lower Walnut River
LM022501	Quarry Lake	CHL	4	37.70900	-95.72300	Wilson	Upper Verdigris
LM022701	Lake Quivira	CHL	4	39.04500	-94.77400	Wyandotte	Lower Kansas
LM038841	Mined Land Lake No. 42	CHL	4	37.25300	-94.94000	Cherokee	Middle Neosho
LM039701	Lake Jayhawk	CHL	4	39.19700	-95.39900	Jefferson	Delaware
LM039901	Hargis Creek Lake	CHL	4	37.27900	-97.38700	Sumner	Middle Arkansas-Slate
LM041201	Lebo City Lake	CHL	4	38.42500	-95.88700	Coffey	Upper Marais Des Cygnes

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LM042201	Wellington Lake	CHL	4	37.21400	-97.52600	Sumner	Chikaskia
LM043401	Lake Kahola	CHL	4	38.52500	-96.41500	Morris	Neosho Headwaters
LM043701	Washburn Rural Env. Lab Lake	CHL	4	38.96300	-95.75200	Shawnee	Middle Kansas
LM046201	Bronson City Lake	CHL	4	37.88700	-95.03300	Bourbon	Marmaton
LM048001	Moline City Lake #2	CHL	4	37.35100	-96.34200	Elk	Elk
LM049601	Thayer New City Lake	CHL	4	37.48300	-95.50200	Neosho	Upper Verdigris
LM050301	Inman Lake	CHL	4	38.24600	-97.71700	McPherson	Little Arkansas
LM053001	Texas Lake Wildlife Area	CHL	4	37.66300	-98.97800	Pratt	South Fork Ninnescah
LM054001	Lake Dabinawa	CHL	4	39.13200	-95.24000	Jefferson	Lower Kansas
LM054101	Cadillac Lake	CHL	4	37.73500	-97.45900	Sedgwick	Middle Arkansas-Slate
LM060701	Belleville City Lake	CHL	4	39.82900	-97.61900	Republic	Middle Kansas
LM060801	Carbondale West Lake	CHL	4	38.81900	-95.71500	Osage	Delaware
LM061001	Elkhorn Lake	CHL	4	39.47200	-95.74200	Jackson	Lower Little Blue
LM061101	Gage Park Lake	CHL	4	39.05800	-95.73000	Shawnee	Lower Kansas
LM061201	Lake Idlewild	CHL	4	39.70900	-96.74500	Marshall	Lower Kansas
LM061301	New Olathe Lake	CHL	4	38.88100	-94.87500	Johnson	Lower Kansas
LM061801	Pierson Park Lake	CHL	4	39.06800	-94.71200	Wyandotte	Middle Kansas
LM062001	Warren Park Lake	CHL	4	39.02000	-95.71800	Shawnee	Lower Kansas
LM062101	Wamego City Lake	CHL	4	39.20200	-96.30100	Pottawatomie	Middle Kansas
LM062301	Dornwood Park Lake	CHL	4	39.02400	-95.63800	Shawnee	Lower Kansas
LM062401	Heritage Park Lake	CHL	4	38.83400	-94.74800	Johnson	Delaware
LM062501	Rose's Lake	CHL	4	38.96950	-94.75800	Johnson	Lower Kansas
LM062601	Little Lake	CHL	4	39.66900	-95.51900	Brown	Lower Missouri-Crooked
LM062701	North Park Lake	CHL	4	39.07600	-94.89200	Wyandotte	Lower Republican
LM062801	Stohl Park Lake	CHL	4	38.91700	-94.72900	Johnson	Little Arkansas
LM063101	Dillon Park Lake #1	CHL	4	38.08800	-97.87700	Reno	Middle Arkansas-Slate
LM063201	Emery Park Lake	CHL	4	37.61600	-97.31000	Sedgwick	Little Arkansas
LM063401	Harvey County Camp Hawk Lake	CHL	4	37.99510	-97.36240	Harvey	Middle Arkansas-Slate
LM063501	Horseshoe Lake	CHL	4	37.72160	-97.41353	Sedgwick	South Fork Ninnescah
LM063601	Kid's Pond	CHL	4	37.72276	-97.41661	Sedgwick	South Fork Ninnescah

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LM063901	Lemon Park Lake	CHL	4	37.63550	-98.73000	Pratt	Middle Arkansas-Slate
LM064101	Moss Lake	CHL	4	37.71700	-97.41600	Sedgwick	Middle Arkansas-Slate
LM064301	Vic's Lake	CHL	4	37.72120	-97.41830	Sedgwick	Middle Arkansas-Slate
LM064401	Oj Watson Park Lake	CHL	4	37.64380	-97.34090	Sedgwick	Middle Arkansas-Slate
LM064501	Windmill Lake	CHL	4	37.71500	-97.41800	Sedgwick	Middle Arkansas-Slate
LM064801	Sterling City Lake	CHL	4	38.20350	-98.20240	Rice	Lower Marais Des Cygnes
LM065201	Frisco Lake	CHL	4	38.87066	-94.80504	Johnson	Marmaton
LM065401	Gunn Park East Lake	CHL	4	37.82860	-94.72110	Bourbon	Upper Marais Des Cygnes
LM065501	Gunn Park West Lake	CHL	4	37.82730	-94.72490	Bourbon	Lower Marais Des Cygnes
LM065601	Lebo City Park Lake	CHL	4	38.41500	-95.87190	Coffey	Upper Marais Des Cygnes
LM065701	Louisburg Old Lake	CHL	4	38.60810	-94.67310	Miami	Upper Marais Des Cygnes
LM065901	Lyndon City Lake	CHL	4	38.58800	-95.68300	Osage	Upper Marais Des Cygnes
LM066301	Parker City Lake	CHL	4	38.31880	-94.99950	Linn	Lower Marais Des Cygnes
LM066401	Pleasanton Lake #1	CHL	4	38.17400	-94.72800	Linn	Little Osage
LM066501	Pleasanton Lake #2	CHL	4	38.17300	-94.72400	Linn	Upper Marais Des Cygnes
LM066601	Prescott City Lake	CHL	4	38.06100	-94.67900	Linn	Upper Marais Des Cygnes
LM066801	Spring Creek Park Lake	CHL	4	38.75400	-95.16200	Douglas	Independence-Sugar
LM067101	Big Eleven Lake	CHL	4	39.11760	-94.63730	Wyandotte	Lower Missouri-Crooked
LM067201	Lansing City Lake	CHL	4	39.24400	-94.88300	Leavenworth	Lower Missouri-Crooked
LM067501	South Lake Park	CHL	4	38.97219	-94.67353	Johnson	Lower Kansas
LM067701	Antioch Park North Lake	CHL	4	39.01117	-94.68365	Johnson	Independence-Sugar
LM067801	Jerry's Lake	CHL	4	39.30000	-94.92200	Leavenworth	Middle Neosho
LM068001	Altamont City Main Lake	CHL	4	37.14000	-95.28800	Labette	Middle Neosho
LM068201	Altamont City West Lake	CHL	4	37.14000	-95.29300	Labette	Marmaton
LM068501	Frisco Lake	CHL	4	37.62100	-94.82900	Crawford	Neosho Headwaters
LM068701	Jones Park Lake	CHL	4	38.42600	-96.20200	Lyon	Lower Cottonwood
LM068901	Peter Pan Pond	CHL	4	38.39450	-96.18800	Lyon	Middle Neosho
LM069001	Playter's Lake	CHL	4	37.40290	-94.71330	Crawford	Upper Neosho
LM069101	Timber Lake	CHL	4	37.65910	-95.21050	Neosho	Upper North Fork Solomon
LM069201	Yates Center Reservoir	CHL	4	37.86640	-95.75000	Woodson	Upper South Fork Solomon

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LM069301	Logan City Lake	CHL	4	39.62900	-99.58100	Phillips	Upper South Fork Solomon
LM069701	Herington City Lake	CHL	4	38.66800	-96.99800	Dickinson	Lower Smoky Hill
LM069801	Lakewood Park Lake	CHL	4	38.84700	-97.58800	Saline	Upper Saline
LM070001	Plainville Township Lake	CHL	4	39.22525	-99.31931	Rooks	North Fork Smoky Hill
LM070301	Big Creek Oxbow	CHL	4	38.86800	-99.34200	Ellis	Lower Republican
LM070601	Boy Scout Lake	CHL	4	38.06900	-100.00000	Hodgeman	Buckner
LM071001	Beymer Lake	CHL	4	37.89590	-101.25678	Kearney	South Fork Beaver
LM071101	Lake Charles	CHL	4	37.77528	-100.03920	Ford	Prairie Dog
LM071601	Lake Tanko	CHL	4	37.25910	-95.55230	Montgomery	Elk
LM071701	Edna City Lake	CHL	4	37.03600	-95.39400	Labette	Elk
LM072201	Thayer Old City Lake	CHL	4	37.48250	-95.48710	Neosho	Neosho Headwaters
LM072301	Winfield Park Lagoon	CHL	4	37.24950	-96.99900	Cowley	Upper North Fork Solomon
LM072601	Caney City Lake	CHL	4	37.12600	-96.01900	Chautauqua	Lower Smoky Hill
LM072701	Barton Lake	CHL	4	38.45280	-98.77800	Barton	Middle Verdigris
LM072901	Le Clere Lake	CHL	4	37.05290	-95.64090	Montgomery	Upper Neosho
LM073101	New Strawn Park Lake	CHL	4	38.26100	-95.74360	Coffey	Spring
LM073201	Paola City Lake	CHL	4	38.61450	-94.89300	Miami	Lower Kansas
LM073301	Pittsburg College Lake	CHL	4	37.39030	-94.69830	Crawford	Lower Marais Des Cygnes
LM073501	Spring Hill City Lake	CHL	4	38.75900	-94.84100	Johnson	Lower Big Blue
LM073601	Sunflower Park Lake	CHL	4	38.94100	-95.01500	Johnson	Lower Big Blue
LM073801	Troy Fair Lake	CHL	4	39.78860	-95.10050	Doniphan	Lower Walnut Creek
LM074001	Stone Lake	CHL	4	38.35240	-98.77160	Barton	Buckner
LM074101	Empire Lake	CHL	4	37.06400	-94.70300	Cherokee	Little Osage
LM075001	Lake Jivaro	CHL	4	39.00700	-95.55200	Shawnee	Delaware
LM075101	Sabetha Watershed Pond	CHL	4	39.87933	-95.79756	Nemaha	Middle Kansas
LM075201	Myer's Pond	CHL	4	39.01030	-95.59700	Shawnee	Lower Kansas
LM075301	Lakeview Estates Lake	CHL	4	38.94400	-95.76810	Shawnee	Lower Kansas
LM986012	Francis Wachs Wildlife Area	CHL	4	39.92400	-99.05800	Smith	Lower Saline
LM010634	Meade State Park Artesian Well	NO	9	37.17200	-100.45300	Meade	Crooked
LM014601	Muscotah Marsh	NO	9	39.52800	-95.51700	Atchison	Delaware

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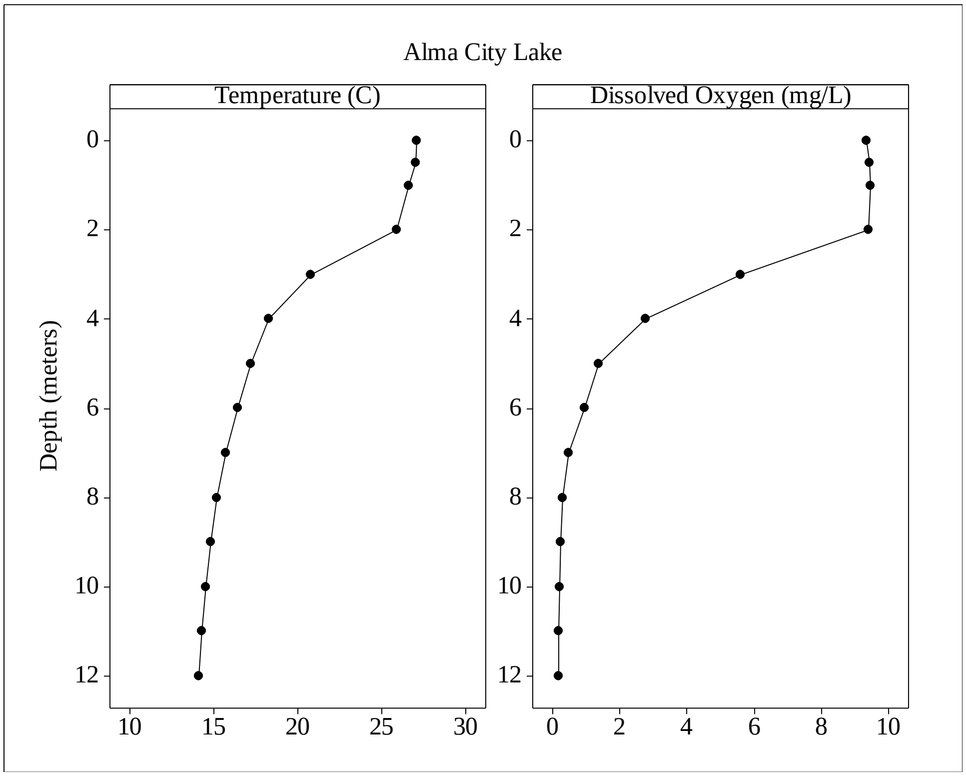
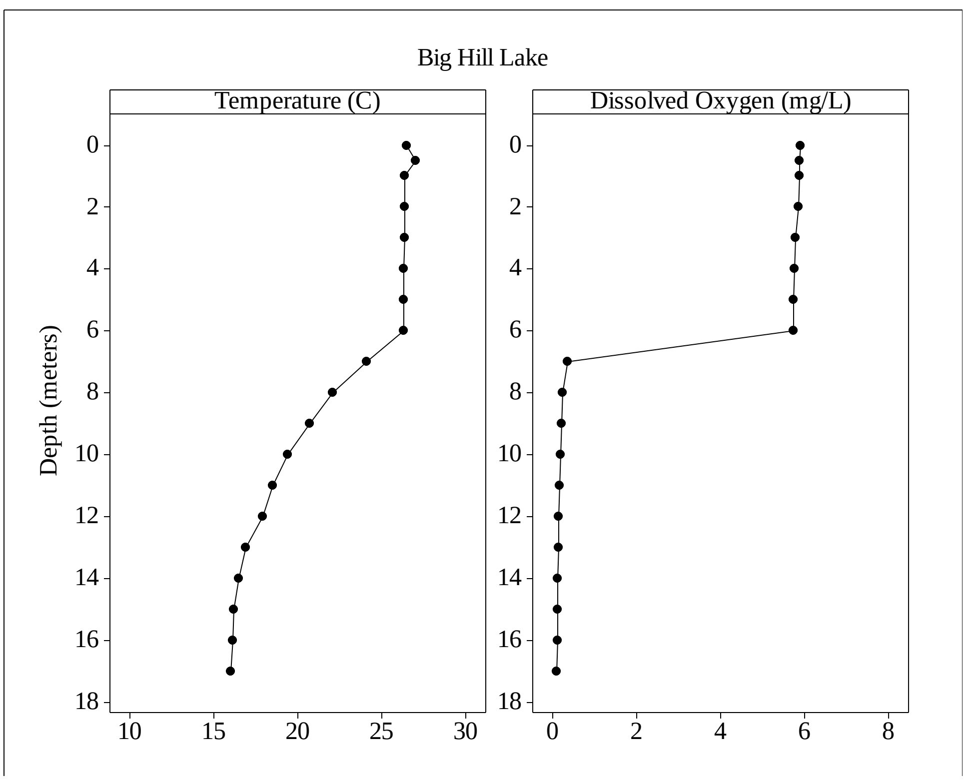
LM014801	Kaw Wildlife Area	NO	9	37.03900	-96.95700	Cowley	Kaw Lake
LM014901	Copan Wildlife Area	NO	9	37.01400	-95.95700	Montgomery	Caney
LM016141	Hamilton Co. SFL Wetland	NO	9	38.04200	-101.82100	Hamilton	Middle Arkansas-Lake McKinney
LM020201	Lake Sherwood	NO	9	39.00100	-95.77700	Shawnee	Middle Kansas
LM020301	Pillsbury Crossing Wildlife Area	NO	9	39.12900	-96.44000	Riley	Middle Kansas
LM020601	Rocky Ford Wildlife Area	NO	9	39.23900	-96.58700	Riley	Lower Big Blue
LM022801	Hole In The Rock	NO	9	38.78200	-95.27200	Douglas	Upper Marais Des Cygnes
LM023041	Fall River Wildlife Area	NO	9	37.73000	-96.18000	Greenwood	Fall
LM029041	Perry Wildlife Area Wetland	NO	9	39.35500	-95.48900	Jefferson	Delaware
LM035101	Mined Land Lake 1	NO	9	37.47700	-94.70400	Crawford	Spring
LM035201	Mined Land Lake 2	NO	9	37.44100	-94.64000	Crawford	Spring
LM035301	Mined Land Lake 3	NO	9	37.44100	-94.62700	Crawford	Spring
LM035501	Mined Land Lake 8	NO	9	37.38900	-94.77200	Crawford	Spring
LM035601	Mined Land Lake 9	NO	9	37.28700	-94.77600	Cherokee	Spring
LM035701	Mined Land Lake 10	NO	9	37.26900	-94.80900	Cherokee	Middle Neosho
LM035801	Mined Land Lake 11	NO	9	37.26600	-94.84000	Cherokee	Middle Neosho
LM036001	Mined Land Lake 13	NO	9	37.26300	-94.81200	Cherokee	Middle Neosho
LM036101	Mined Land Lake 14	NO	9	37.24800	-94.82100	Cherokee	Middle Neosho
LM036201	Mined Land Lake 15	NO	9	37.25100	-94.81000	Cherokee	Spring
LM036401	Mined Land Lake 18	NO	9	37.26800	-94.92200	Cherokee	Middle Neosho
LM036501	Mined Land Lake 19	NO	9	37.28100	-94.89200	Cherokee	Middle Neosho
LM036601	Mined Land Lake 20	NO	9	37.24100	-94.98400	Cherokee	Middle Neosho
LM036701	Mined Land Lake 21	NO	9	37.24700	-94.97300	Cherokee	Middle Neosho
LM036801	Mined Land Lake 22	NO	9	37.22500	-94.99200	Cherokee	Middle Neosho
LM036901	Mined Land Lake 23	NO	9	37.23300	-94.98200	Cherokee	Middle Neosho
LM037001	Mined Land Lake 24	NO	9	37.21100	-95.01300	Cherokee	Middle Neosho
LM037101	Mined Land Lake 25	NO	9	37.20000	-95.05400	Cherokee	Middle Neosho
LM037201	Mined Land Lake 26	NO	9	37.33300	-94.80100	Cherokee	Spring
LM037401	Mined Land Lake 28	NO	9	37.20200	-95.01500	Cherokee	Middle Neosho
LM037501	Mined Land Lake 29	NO	9	37.20800	-94.99900	Cherokee	Middle Neosho

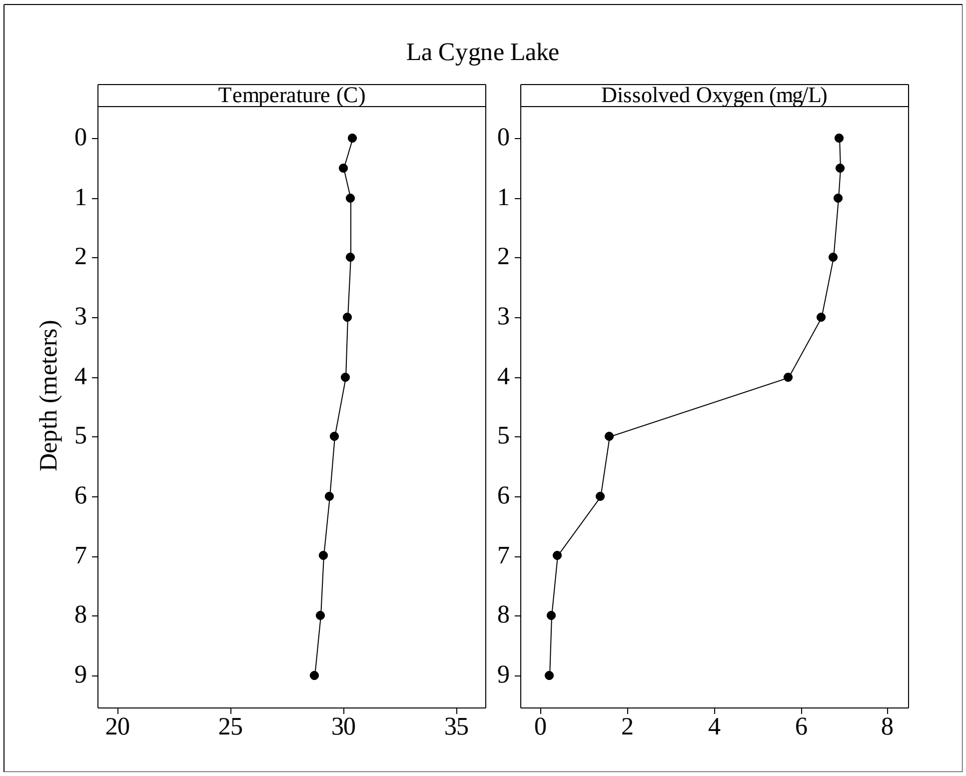
Station	Waterbody	Group	Tier	Latitude	Longitude	County	HUC 8
LM037701	Mined Land Lake 31	NO	9	37.21000	-94.98300	Cherokee	Middle Neosho
LM037801	Mined Land Lake 32	NO	9	37.21800	-94.97000	Cherokee	Middle Neosho
LM037901	Mined Land Lake 33	NO	9	37.22500	-95.03200	Cherokee	Middle Neosho
LM038001	Mined Land Lake 34	NO	9	37.22800	-95.03100	Cherokee	Middle Neosho
LM038101	Mined Land Lake 35	NO	9	37.22400	-94.99900	Cherokee	Middle Neosho
LM038201	Mined Land Lake 36	NO	9	37.23800	-95.03400	Cherokee	Middle Neosho
LM038301	Mined Land Lake 37	NO	9	37.25100	-94.94200	Cherokee	Middle Neosho
LM038401	Mined Land Lake 38	NO	9	37.25000	-94.92900	Cherokee	Middle Neosho
LM038501	Mined Land Lake 39	NO	9	37.25300	-94.98500	Cherokee	Middle Neosho
LM038601	Mined Land Lake 40	NO	9	37.25300	-94.96700	Cherokee	Middle Neosho
LM038701	Mined Land Lake 41	NO	9	37.26200	-94.95800	Cherokee	Middle Neosho
LM038801	Mined Land Lake 42	NO	9	37.26200	-94.92400	Cherokee	Middle Neosho
LM038901	Mined Land Lake 43	NO	9	37.26600	-94.91900	Cherokee	Middle Neosho
LM039001	Mined Land Lake 45	NO	9	37.29300	-94.91400	Cherokee	Middle Neosho
LM047401	Mined Land Lake 5	NO	9	37.42550	-94.76000	Crawford	Spring
LM048201	Mined Land Lake 17	NO	9	37.29400	-94.90300	Cherokee	Middle Neosho
LM050101	Topeka Public Golf Course Lake	NO	9	39.02000	-95.78400	Shawnee	Middle Kansas
LM050501	KFG Hatchery And Ponds	NO	9	37.63300	-98.69500	Pratt	South Fork Ninnescah
LM053301	Marais Des Cygnes NWR	NO	9	38.23300	-94.64900	Linn	Lower Marais Des Cygnes
LM070101	Smoky Hill Garden Lake	NO	9	39.18760	-101.75700	Sherman	Big
LM071401	Saint Francis Wildlife Area	NO	9	39.74000	-101.87200	Cheyenne	Middle Verdigris
LM071801	Moline City Sf Lake	NO	9	37.36550	-96.33010	Elk	Caney
LM072501	Kirwin NWR	NO	9	39.68300	-99.24400	Phillips	Cow
LM985293	Elk City Wildlife Area	NO	9	37.25700	-95.85800	Montgomery	Lower North Fork Solomon
LM986418	Norton Wildlife Area	NO	9	39.78100	-100.00400	Norton	Lower Republican
LM986432	Tuttle Creek Wildlife Area	NO	9	39.48100	-96.67500	Riley	Upper Cottonwood
LM986449	Milford Wildlife Area	NO	9	39.26500	-97.01400	Clay	Upper Marais Des Cygnes
LM986470	Marion Wildlife Area	NO	9	38.45700	-97.19700	Marion	Neosho Headwaters
LM986487	Melvern Wildlife Area	NO	9	38.49800	-95.89700	Osage	Upper Verdigris
LM986494	John Redmond Wildlife Area	NO	9	38.22420	-95.82920	Coffey	Smoky Hill Headwaters

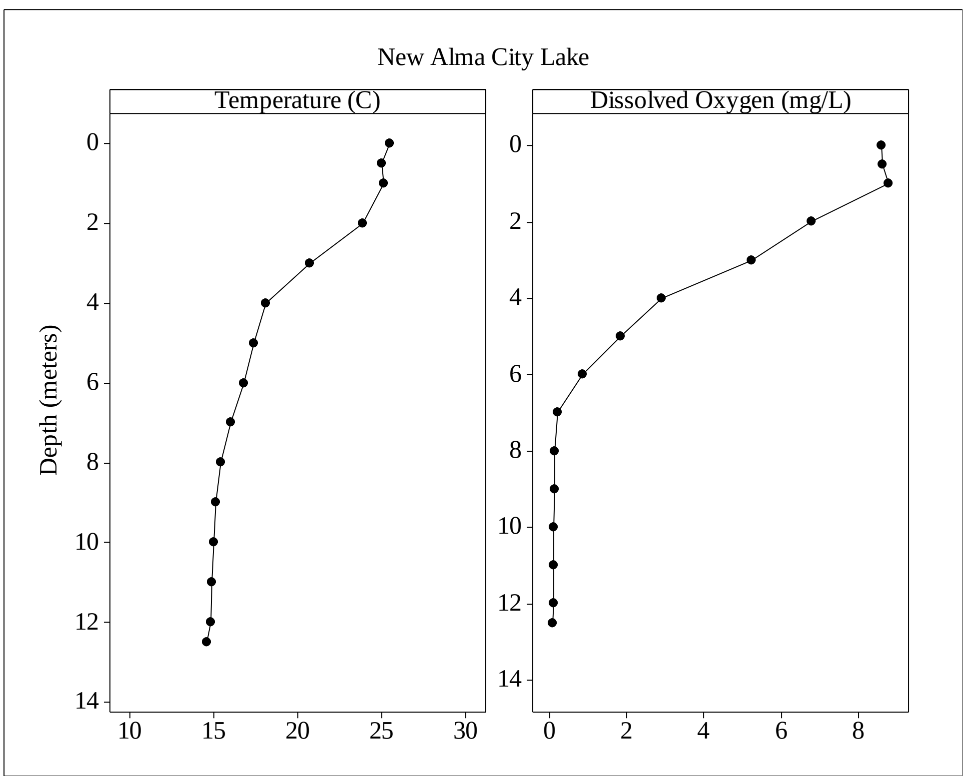
Station	Waterbody	Group	Tier	Latitude	Longitude	County	HUC 8
LM986500	Toronto Wildlife Area	NO	9	37.81800	-95.95300	Greenwood	Upper Smoky Hill

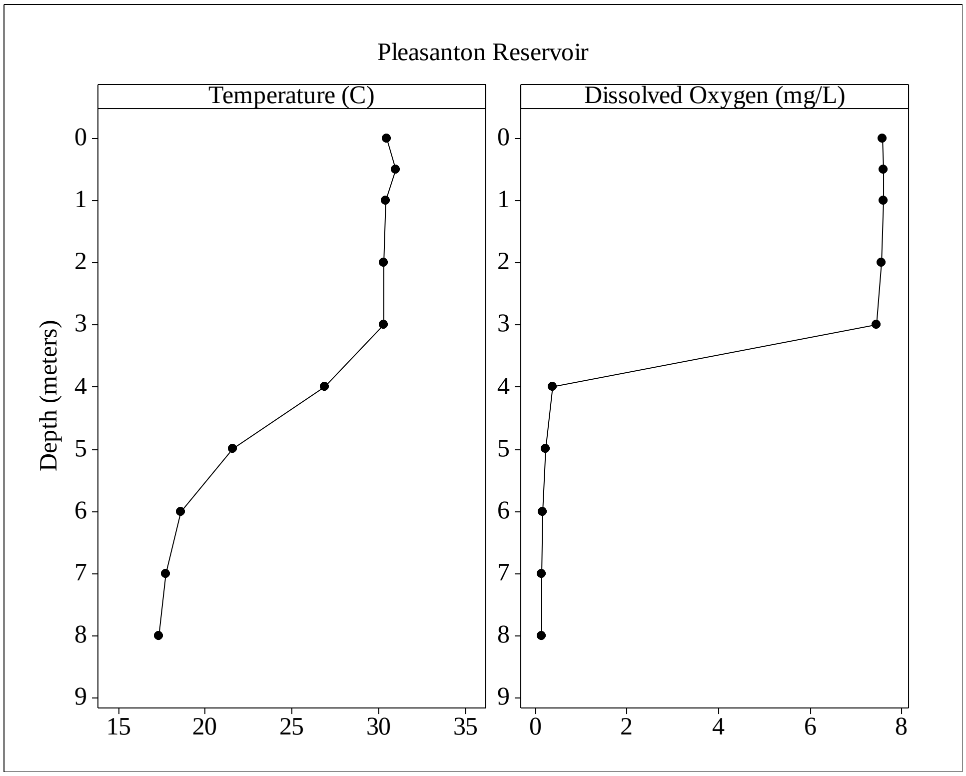
Appendix B: Temperature and Dissolved Oxygen Profiles of Stratified Lakes

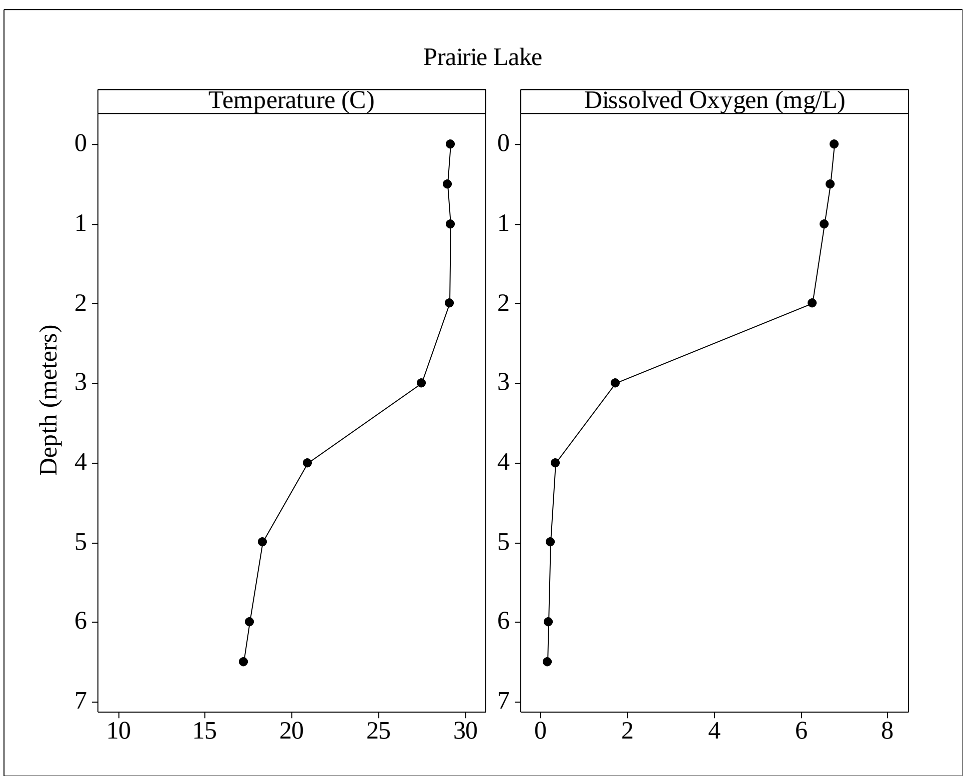


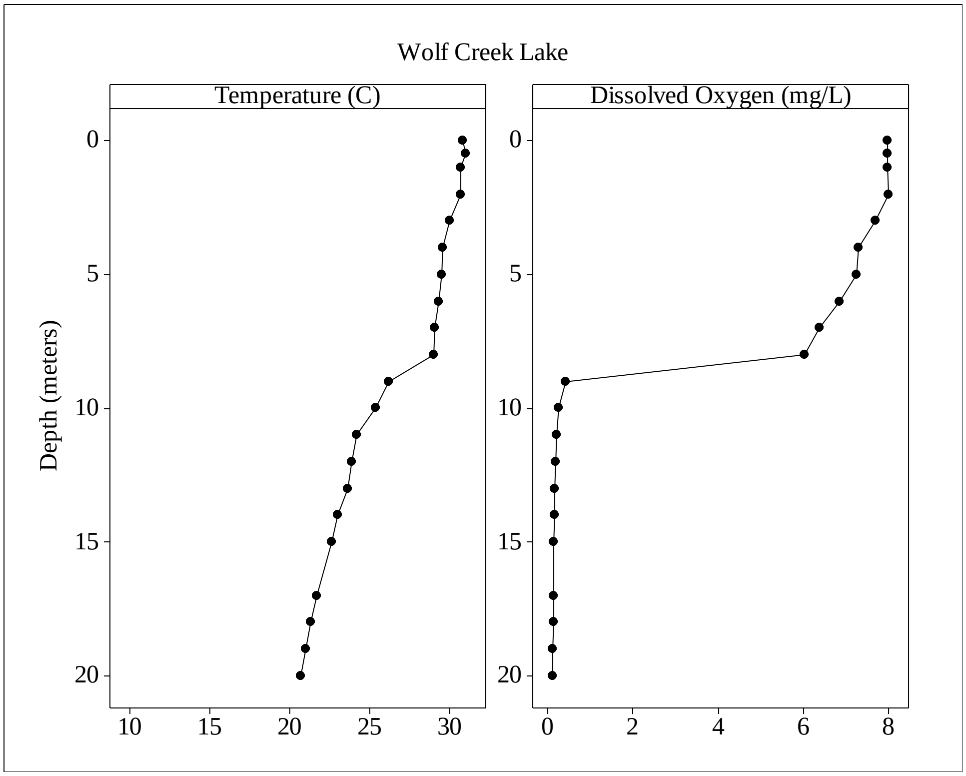


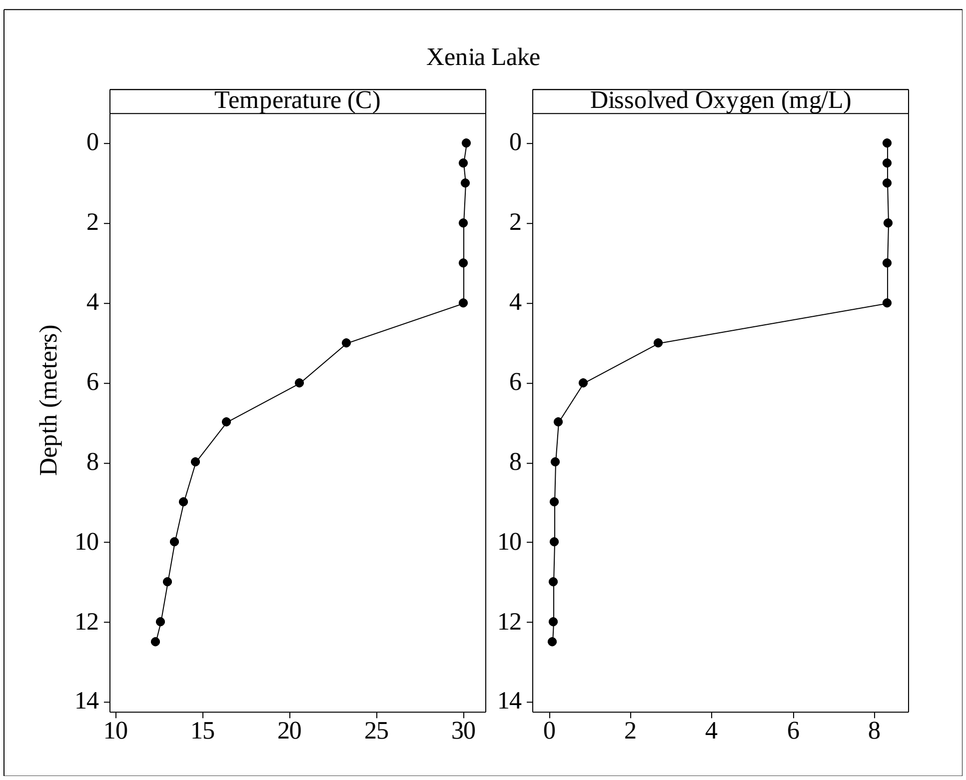

La Cygne Lake
Temperature (C)
Dissolved Oxygen (mg/L)
Depth (meters)
0
1
2
3
4
5
6
7
8
9
20
25
30
35
0
2
4
6
8


New Alma City Lake
Temperature (C)
Dissolved Oxygen (mg/L)
Depth (meters)
0
2
4
6
8
10
12
14
10
15
20
25
30
0
2
4
6
8


Pleasanton Reservoir
Temperature (C)
Dissolved Oxygen (mg/L)
Depth (meters)
0
1
2
3
4
5
6
7
8
9
15
20
25
30
35
0
2
4
6
8


Prairie Lake
Temperature (C)
Dissolved Oxygen (mg/L)
Depth (meters)
0
1
2
3
4
5
6
7
10
15
20
25
30
0
2
4
6
8


Wolf Creek Lake
Temperature (C)
Dissolved Oxygen (mg/L)
Depth (meters)
0
5
10
15
20
10
15
20
25
30
0
2
4
6
8


Xenia Lake
Temperature (C)
Dissolved Oxygen (mg/L)
Depth (meters)
0
2
4
6
8
10
12
14
10
15
20
25
30
0
2
4
6
8